VOLUME 1
MULTI-SITES INVESTIGATION REPORT
CAMP BONNEVILLE, WASHINGTON

Contract No. DACA67-94-D-1014

July 1999

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Multi-Sites
Investigation Report
Camp Bonneville
Vancouver, Washington
Contract No. DACA67-94-D-1014

July 1999

Department of the Army
Seattle District Corps of Engineers
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Seattle, Washington 98124-2255

EXECUTIVE SUMMARY

The Camp Bonneville Military Reservation (Camp Bonneville) in Clark County, Washington, is a United States government military facility that was selected for closure under the Base Realignment and Closure (BRAC) process. Camp Bonneville was established in 1909 as a drill field and rifle range, and has been used since then as a training camp for Department of Defense and government personnel. As a result of past waste and resource management practices in support of these activities, some areas have been contaminated by hazardous substances or wastes.

This report documents the findings of site investigations conducted at Camp Bonneville between October 1997 and November 1998. This work was performed for the United States Army Corps of Engineers (Corps), Seattle District, under Contract No. DACA67-94-D-1014, Delivery Order Nos. 0010, 0017, and 0025. The scopes of work executed under these Delivery Orders are described in three separate Management Plans (Shannon & Wilson, 1997, 1998a, and 1998b).

The overall objective of this investigation, which has been conducted as part of the BRAC process, has been to identify contaminated areas and determine the next appropriate step toward restoration of those sites. This report describes the results of the environmental investigations of 17 known or suspected contaminated areas at Camp Bonneville. The investigation of one additional site (Landfill 4) will be described in an addendum to this report.

The sites that were investigated included three old landfills, two suspected disposal areas, a former burn area, three burned buildings, two grease pit locations, a former vehicle maintenance pit, two former vehicle wash racks, a former sewage pond, three ammunition storage magazines, two hazardous material storage buildings, and 26 aboveground storage tanks. Investigation activities included unexploded ordnance (UXO) avoidance in areas outside of the cantonments; geophysical surveys where the suspected contaminant sources were underground; soil sampling at all of the sites that could be located; well installation and groundwater sampling at the landfills, former sewage pond, and pesticide mixing/storage building; and wipe sampling in the ammunition storage magazines. These investigations were conducted in general accordance with the Management Plans, with adjustments made in the field to accommodate site conditions.

The analytical results obtained from soil and groundwater samples collected at the various sites were compared with project screening levels to determine if each site potentially poses an unacceptable environmental risk. These screening levels include state and federal regulatory and risk-based cleanup criteria for residential exposure. The analytical results for metals in soil were also compared with site background levels established for the facility, and with background concentrations established by the Washington State Department of Ecology.

No further action is recommended at the majority of the sites because either no evidence of contamination was detected or minimal contamination was detected at these locations: Landfills

2 and 3, the Burn Area, Former Buildings 1962 and 1983, the Paint and Solvent Disposal Area, the Grease Pits, 18 of the Aboveground Storage Tank locations, the Former Sewage Pond, the Hazardous Material Accumulation Point, and Wash Rack No. 2. No evidence of the existence of Landfill 1 was found. Based on these findings, future land use restrictions may apply only to use of the areas underlain by landfill debris.

Soil contamination that potentially poses a risk to human health was detected at the remaining sites, including the Drum Disposal Area (metals); Wash Rack No. 1 (total petroleum hydrocarbons [TPH] and metals); the Pesticide Mixing/Storage Building (TPH, one semi-volatile organic compound, pesticides, and metals); eight of the Aboveground Storage Tank locations (diesel-range TPH); the Former CS Training Building (lead, semivolatile organic compounds); the Maintenance Pit (TPH, metals, pesticides, and volatile organic compounds); and the outside of the Ammunition Storage Magazines (metals). The interiors of the Ammunition Storage Magazines also contain soil with explosives (RDX in one magazine) and metals (in both smaller magazines) at concentrations above the project screening levels.

The extent of contamination at most of these sites is very limited in lateral extent, and typically appears to be confined to surface and near-surface soils. Based on these findings and the types of contaminants present, removal and proper disposal of the contaminated soils is recommended. However, additional site characterization is recommended prior to remediation at the Ammunition Storage Magazine and Maintenance Pit sites. This additional characterization should be directed at determining the vertical and horizontal extent of contamination and evaluating the potential for contaminant migration to groundwater and/or nearby streams.

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ACRONYMS AND ABBREVIATIONS

AP/PA	ammonium picrate/picric acid
APP	Accident Prevention Plan
ARAR	applicable or relevant and appropriate requirement
ASR	Archives Search Report
AST	aboveground storage tank
BCT	BRAC Cleanup Team
bgs	below ground surface
BRAC	Base Realignment and Closure
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CCC	Civilian Conservation Corps
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
CFR	Code of Federal Regulations
CLARC	MTCA Cleanup Levels and Risk Calculations
CLP	contract laboratory program
cm	centimeter
CMQAL	Chemical and Materials Quality Assurance Laboratory
Corps	United States Army Corps of Engineers
CS	2-chlorobenzalmalononitrile (tear gas)
CSM	Conceptual Site Model
CX	Center of Expertise
DO	Delivery Order
DoD	Department of Defense
DOT	Department of Transportation
EBS	Environmental Baseline Survey
ECC	Environmental Chemical Corporation
Ecology	Washington State Department of Ecology
EM	electromagnetic induction
EOD	Explosive Ordinance Disposal
EPA	United States Environmental Protection Agency
°F	degrees Fahrenheit
FBI	Federal Bureau of Investigation
FSP	Field Sampling Plan
GPES	GP Environmental Services, Inc.
GPR	ground penetrating radar
HCID	hydrocarbon identification
I.D.	inside diameter
IDW	investigation-derived waste
IEUBk	Integrated Exposure Uptake Biokinetic model
IRPIMS	Installation Restoration Program Information Management System
MCL	Maximum Contaminant Level

MDL	method detection limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
MS/MSD	matrix spike/matrix spike duplicate
MTCA	Model Toxics Control Act
NAPL	nonaqueous phase liquid
NFA	no further action
ng	nanograms
NPL	National Priorities List
NTU	nephelometric turbidity unit
PA	picric acid
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCB	polychlorinated biphenyl
PETN	pentaerythritol tetranitrate
PID	photoionization detector
PPE	personal protection equipment
PPL	priority pollutant list
ppm	parts per million
PSRL	project-specific reporting limits
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
Quanterra	Quanterra Environmental Services, Inc.
RBC	risk-based concentration
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RL	reporting limit
SDG	sample delivery group
SVOC	semivolatile organic compound
TEG	Transglobal Environmental Geosciences, Inc.
TOC	total organic carbon
TPH	total petroleum hydrocarbons
UCL	upper confidence limit
UST	underground storage tank
UXO	unexploded ordnance
VOC	volatile organic compound
WAC	Washington Administrative Code
WTPH-G	Washington total petroleum hydrocarbon method – gasoline
WTPH-D	Washington total petroleum hydrocarbon method – diesel
WTPH-Dx	Washington total petroleum hydrocarbon method – diesel, extended

MULTI-SITES INVESTIGATION REPORT
CAMP BONNEVILLE
VANCOUVER, WASHINGTON

1.0 INTRODUCTION

This report describes the results of the environmental investigations of 17 known or suspected contaminated areas at the Camp Bonneville Military Reservation (Camp Bonneville) in Vancouver, Washington (Figure 1-1). Camp Bonneville is a United States government military facility that was selected for closure under the Base Realignment and Closure (BRAC) authorization.

Camp Bonneville is a sub-installation of Vancouver Barracks, which is a sub-installation of Fort Lewis, Washington. Camp Bonneville was established in 1909 as a drill field and rifle range, and has been used since then as a training camp for active Army, Army Reserve, National Guard, Marine Corps Reserve, Navy Reserve, and Coast Guard Reserve units, as well as other Department of Defense (DoD) and government personnel. The facility is still used by federal, state, and local law enforcement agencies for firearms training and practice, and general training purposes.

This report has been prepared by Shannon & Wilson, Inc., under Contract No. DACA67-94-D-1014 with the United States Army Corps of Engineers (Corps), Seattle District. The work was included in three Delivery Orders (D.O.s); numbers 10, 17, and 25. The work was performed in general accordance with the corresponding Scopes of Work dated September 30, 1996; July 11, 1997; and February 24, 1998, respectively. GeoRecon International performed the geophysical surveys, unexploded ordnance (UXO) avoidance services were provided by Environmental Chemical Corporation (ECC), and soil gas surveying was performed by Transglobal Environmental Geosciences, Inc., (TEG). Inca Engineers conducted the land surveying. Chemical analyses for the project were performed by Quanterra Environmental Services, Inc. (Quanterra); Sound Analytical Services, Inc.; Columbia Analytical Services, Inc.; and GP Environmental Services, Inc. (GPES). Data evaluation was completed, in part, by Radian International LLC.

The Multi-Sites I investigation (D.O. number 10) included environmental assessments at three landfills (numbers 1, 2, and 3); a burn area; the area around former Buildings 1962 and 1983; a drum disposal area; and a paint and solvent disposal area. The Multi-Sites II investigation (D.O. number 17) included a vehicle maintenance pit, a vehicle wash rack (number 1), two grease pits, a pesticide mixing/storage building, numerous aboveground storage tanks (ASTs), a former sewage pond, three ammunition storage magazines, a hazardous material accumulation point, and a landfill (number 4). The Multi-sites III investigation (D.O. number 25) included a former

CS training building and a wash rack (number 2). Investigations have taken place at all of the sites. The field work at Landfill 4 was delayed because of UXO concerns. Results of that investigation will be provided in a separate report.

The rationale and approach for the investigations of these sites were described in three Management Plans. The Management Plan for the Investigation of Landfills, Burn Areas, and Drum Burial Sites (Shannon & Wilson, 1997) included the seven Multi-Sites I sites. The Management Plan for the Multi-Sites II Investigation (Shannon & Wilson, 1998a) included the nine Multi-Sites II sites. The Management Plan for the Multi-Sites III Investigation (Shannon & Wilson, 1998b) included the two Multi-Sites III sites. Each Management Plan consisted of a Work Plan, Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and Accident Prevention Plan (APP).

1.1 PROJECT OBJECTIVES

The overall objective of the BRAC process is to complete the environmental restoration of subject sites (where hazardous substances or petroleum products are found) in order to eliminate detrimental effects to human health and the environment. The investigations described in this report represent the second step in reaching a determination that the property is suitable for transfer or lease.

Property being transferred from the federal government to non-federal parties is governed by the Comprehensive Environmental Response, Compensation, and Liability Act **(**CERCLA), whether the property is a designated CERCLA site (on the National Priorities List [NPL]) or is a non-CERCLA site, such as Camp Bonneville. CERCLA, and the 1992 Community Environmental Response Facilitation Act (CERFA) amendment to CERCLA, require that deeds for federal transfer of previously contaminated property contain a covenant that states that all remedial actions (which may include installation of an approved remediation system) necessary to protect human health and the environment have been taken.

Camp Bonneville is not on the NPL; however, the BRAC environmental restoration program is being conducted consistent with CERCLA guidelines for investigations and remediation, and follows the CERFA guidelines. Cleanup levels established by the Washington Department of Ecology (Ecology) under the Model Toxics Control Act (MTCA) have been used as screening criteria to evaluate the levels of contaminants detected at Camp Bonneville, and the need for additional investigation or remediation. Other criteria used for screening levels include U.S. Environmental Protection Agency (EPA) Region 3 risk-based concentrations; Ecology's natural background soil metals concentrations (Ecology, 1994); and background metals concentrations established for soil at Camp Bonneville.

Specific objectives of this investigation were to (1) characterize contaminants of potential concern at each site, (2) determine whether contaminant migration has occurred or is likely to occur, (3) provide a conceptual site model and a preliminary risk evaluation by comparison with

EPA Region 3 and MTCA risk-based criteria; and (4) provide recommendations for follow-on actions, including a No Further Action (NFA) alternative, if appropriate. The information provided in this report will be used by the Camp Bonneville BRAC Cleanup Team (BCT) to determine follow-on actions, if required. The BCT is composed of representatives of Fort Lewis, the EPA, and Ecology.

1.2 SCOPE OF WORK

The scope of work was designed to be as flexible as possible to allow field adjustments for conditions encountered as the investigations proceeded. The specific tasks included the following:

- Perform UXO avoidance activities at sites outside of the cantonment areas prior to initiation of other investigative activities.
- Perform geophysical surveys to delineate the extent of landfill and disposal sites.
- Perform soil gas surveys at two landfill sites.
- Collect wipe samples from the concrete floors of the ammunition storage magazines.
- Collect surface/near-surface soil samples at most of the sites and from background locations.
- Drill soil borings and collect subsurface soil samples at most of the sites.
- Install and develop groundwater monitoring wells at selected sites.
- Collect groundwater samples from all new monitoring wells.
- Collect a sample from the sump at the hazardous material accumulation point.

1.3 REPORT ORGANIZATION

This report is organized into nine sections, with nine appendices containing supporting information. A brief description of each section follows.

- **Section 1 – Introduction**. An introduction to the project, a description of the work scope, and a review of the report organization is provided.
- **Section 2 – Site Background**. A description of the facility and its history is provided. An introduction to the investigation sites is provided, along with a summary of previous investigations.

- **Section 3 – Environmental Setting and Conceptual Site Model**. A description of the general environmental setting of the facility is provided, including the physical setting, climate, geology, and hydrogeology. A conceptual site model is also presented.

- **Section 4 – Investigation Methods**. Descriptions of the investigation and sampling techniques used, as well as the laboratory methods followed, are provided.

- **Section 5 – Comparison Criteria.** Descriptions of the regulatory and risk-based criteria for soil and groundwater are provided. A discussion of background levels used for comparison with soil metals concentrations is also included.

- **Section 6 – Site Investigation Activities and Results**. A description of investigation activities performed at each site, along with a summary of the results from these activities, is provided. Contaminants detected at each site are identified and compared with screening levels. A summary of the data quality and completeness is also provided.

- **Section 7 – Conclusions and Recommendations**. A summary of the findings and areas requiring further investigation or remediation is provided, as well as those areas requiring no further action.

- **Section 8 – Limitations**. The uncertainties and limitations associated with the investigations and findings are presented.

- **Section 9 – References**. A list of documents used in preparation of this report is provided.

- **Appendix A – Site Photographs**. Selected photographs of each site are provided.

- **Appendix B – Geophysical and Soil Gas Surveys**. Descriptions of the geophysical methods and surveys performed are provided, along with copies of the electromagnetic survey plots and ground penetrating survey graphs. Results of the soil gas survey and sampling locations are also included.

- **Appendix C – Field Documentation**. Copies of the field sampling forms, log books, and chemical quality control reports are provided.

- **Appendix D – Boring Logs**. Copies of boring logs are provided for all soil borings, and monitoring well construction information is included on applicable logs.

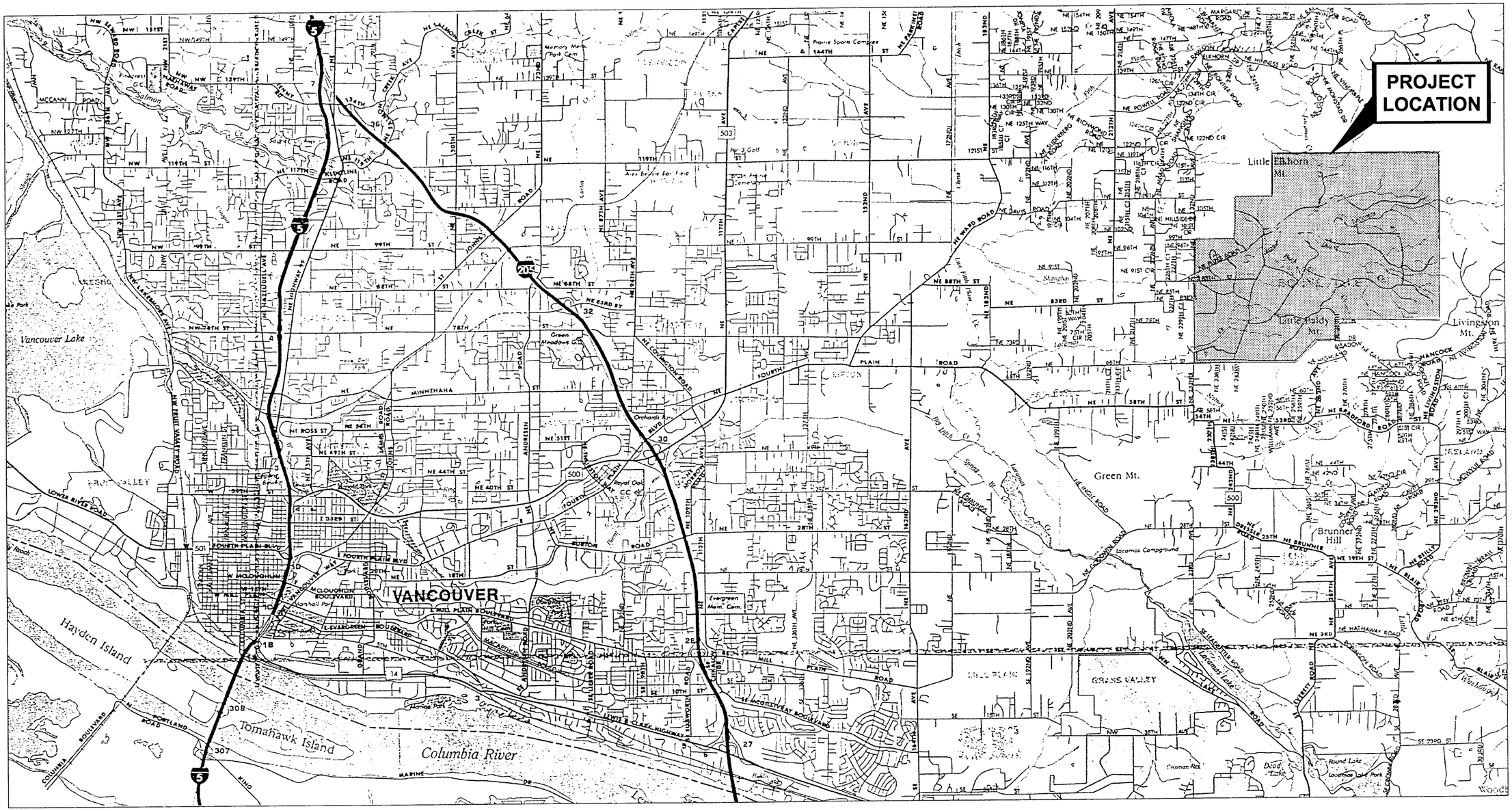
- **Appendix E – Survey Data**. Tables of the survey data, including sample locations and elevations, are provided. Copies of the surveyor field notes are also included.

- **Appendix F – Management Plan Adjustments**. Descriptions of changes to procedures described in the Management Plans are provided, for both field and analytical methods.

- **Appendix G – Data Quality Evaluations**. Results of the data quality reviews are provided, by method, for the Multi-Sites I, II, and III investigations.

- **Appendix H – Data Summary Tables**. Laboratory data are summarized in tables prepared for each site. Sample results, method detection limits, reporting limits, and data qualifiers are included in the tables.

- **Appendix I – Analytical Reports**. Copies of the laboratory reports are provided, organized by laboratory data package. Tables summarize the samples collected and provide a key to the location of the data for each site.



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0 1 2

Scale in Miles

NOTE

Base map taken from "Clark County, Washington - 1996 Edition." Reprinted with permission from King of the Road Map Service.

Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

VICINITY MAP

July 1999 T-4110-05

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 1-1

2.0 SITE BACKGROUND

2.1 FACILITY DESCRIPTION AND HISTORY

Camp Bonneville, located in Clark County, Washington, is a United States government military facility. Camp Bonneville is a sub-installation of Vancouver Barracks, which is a sub-installation of Fort Lewis, Washington. The camp encompasses approximately 3,840 acres in the foothills of the Cascade Mountains, about 12 miles northeast of Vancouver, Washington. The camp includes two cantonment areas, Camp Killpack cantonment and Camp Bonneville cantonment, which together occupy about 30 acres.

Troops from Vancouver Barracks began to use part of the facility for a target range in 1910. The original reservation, consisting of approximately 3,020 acres, was acquired by the federal government in 1918. It was officially named Camp Bonneville in 1926. The Camp Bonneville cantonment area apparently was built in the late 1920s. The Camp Killpack cantonment area was built and occupied by the Civilian Conservation Corps (CCC) in 1935. The facilities were used for several military training programs, in addition to being used by the Vancouver Barracks. During World War II, the facility was also used to house Italian prisoners of war.

In 1950, many of the buildings and systems at the facility were rehabilitated to use for training Army Reserve units. In the early 1950s, an additional 840 acres of land were leased from the State of Washington. Vancouver Barracks, including Camp Bonneville, became a sub-installation of Fort Lewis, Washington, in 1959.

Since World War II, Camp Bonneville has been used as a training camp for active Army, Army Reserve, National Guard, Marine Corps Reserve, Navy Reserve, and Coast Guard Reserve units, as well as other DoD and government personnel. In the 1980s, the facility was used by a number of civilian organizations for camping, picnics, and environmental studies. Camp Bonneville is currently used by federal, state, and local law enforcement agencies for firearms training and practice, and general training purposes. The Federal Bureau of Investigation (FBI) makes frequent use of one of the firing ranges.

In 1996, following the selection of Camp Bonneville for closure (in 1995) under the BRAC authorization, all active military training units ceased operations at the camp. All out-grants for use of the facilities were cancelled with the exception of the FBI range. The FBI currently plans to maintain a firing range on Camp Bonneville property after the base has been officially released by the DoD.

As part of the BRAC evaluation process, discreet areas at Camp Bonneville were classified according to their environmental condition, and BRAC parcel numbers were assigned. This process is described further in Section 2.3, Previous Investigations.

2.2 INVESTIGATION SITES

Environmental investigations of 17 sites are presented in this report. Investigation of one additional site, Landfill 4, was delayed because of UXO concerns. Descriptions of the investigation activities and results for that site will be provided in a separate report. Table 2-1 provides a list of the investigation sites, along with the project (Multi-Sites I, II, or III) with which they are associated. The site locations are shown on Figures 2-1 through 2-3. Sites located outside of the cantonment areas (Figure 2-1) include the Burn Area, Drum Disposal Area, Paint and Solvent Disposal Area, Former Sewage Pond, Ammunition Storage Magazines, Former CS Training Building, and the landfills. Sites within the Camp Killpack cantonment (Figure 2-2) include the Maintenance Pit, Wash Rack Nos. 1 and 2, one of the Grease Pits, three ASTs, and the Hazardous Material Accumulation Point. Sites within the Camp Bonneville cantonment area (Figure 2-3) include 2 burned building sites (Buildings 1962 and 1983), 2 Grease Pits, the Pesticide Mixing/Storage Building, and 23 ASTs. Photographs of the sites are provided in Appendix A.

Summaries of the potential contaminant sources, constituents of potential concern identified before the start of the field investigations, and descriptions and operational histories for each site are provided in Table 2-2. Additional descriptions of the site characteristics and history are provided in Section 6.

2.3 PREVIOUS INVESTIGATIONS

An Environmental Baseline Survey (EBS) of Camp Bonneville was conducted in 1995, in part to identify sites where there were known or suspected sources or releases of hazardous substances or petroleum products resulting from past and/or current uses of the facility. The EBS was conducted as a first step in the BRAC process. It was based on interviews, visual inspections, and a review of past and current site operations, and included no environmental sampling. The EBS was finalized in January 1997 (Woodward-Clyde, 1997).

Sites identified during performance of the EBS were assigned BRAC parcel numbers based on the apparent environmental condition of the area. The parcels were assigned a category from 1 to 7. BRAC parcels in categories 1 through 4 are considered suitable for transfer or lease. Parcels in categories 5 through 7 are considered not suitable for transfer because of the known or suspected presence of hazardous substances or petroleum.

Most of the sites addressed in this report were identified in the EBS as category 7 sites, specifically, Landfills 1, 2, and 3; the Burn Area; Former Buildings 1962 and 1983; the Drum Disposal Area; the Paint and Solvent Disposal Area; the Maintenance Pit (identified as the Building 4475 site in the EBS); the two Grease Pit sites; the Pesticide Mixing/Storage Building (identified as the Building 1864 site in the EBS); the Former Sewage Pond; the Former CS Training Building; and Wash Rack No. 2. The ASTs were identified in the EBS as a category 2 site. BRAC parcel numbers are provided in Table 2-1.

Three sites do not have BRAC numbers. Wash Rack No. 1 was not included in the EBS, but was described in the BRAC Cleanup Plan Report (Woodward-Clyde, 1996). The Ammunition Storage Magazines and the Hazardous Material Accumulation Point, although not identified in the EBS, are included in this investigation because of the potential for residual contamination from materials handling. None of the sites included in this investigation were sampled previously.

TABLE 2-1
INVESTIGATION SITES

Investigation	BRAC Parcel Number	Site Name
Multi-Sites I	2 (7) HR (P)	Landfill 1
	3 (7) HR (P)	Landfill 2
	5 (7) HR (P)	Landfill 3
	4 (7) HR (P)	Burn Area
	8 (7) HR (P)	Former Buildings 1962 and 1983
	18 (7) HR (P)	Drum Disposal Area
	19 (7) HR (P)	Paint and Solvent Disposal Area
Multi-Sites II	12 (7) PR (P)/ HR (P)	Maintenance Pit
	NA	Wash Rack No. 1
	6 (7) HR (P), 11 (7) HR (P)	Grease Pits
	9 (7) HR (P)	Pesticide Mixing/Storage Building
	7 (2) PS	Aboveground Storage Tanks
	17 (7) HR (P)	Former Sewage Pond
	NA	Ammunition Storage Magazines
	NA	Hazardous Material Accumulation Point
	21(7) HR (P)	Landfill 4
Multi-Sites III	25 (7) HR (P)	Former CS Training Building
	14 (7) PR (P)/ HR (P)	Wash Rack No. 2

Notes:
BRAC = Base Realignment and Closure
Each BRAC parcel was assigned a number to which appropriate descriptive labels have been attached as follows:

- < The first number is the unique parcel identification number.
- < The second number (in parentheses) is the categaory number for the environmental condition of the property (see Section 2.3).
- < The first label (two-character set of letters) indicates the type of contamination or storage present in the parcel, where PS represents petroleum storage, PR represents petroleum release or disposal, and HR represents hazardous substance release or disposal.
- < The second label, (P), indicates that the presence of a contaminant is possible, but that data are unavailable for verification.

TABLE 2-2
SITE DESCRIPTIONS

Site	Potential Contaminant Source	Contaminants of Potential Concern	Site Description
Landfill 1	Buried waste, possibly from an old homestead (early 1900s)	Metals and total petroleum hydrocarbons.	Located east of the Bonneville cantonment and north of the existing sewage lagoon. Potential historical significance was identified based on the presence of bottle fragments dating from the early 1900s. This reported disposal area is believed to be small, based on the surface expression of a 12-foot by 15-foot shallow depression described in the 1980 cultural resources survey.
Landfill 2	Military waste and debris of unknown composition; could include solvents, paints, waste oil, petroleum products, pesticides, and ordnance.	Volatile and semivolatile organics, heavy metals, cyanide, PCBs, organochlorine pesticides, total petroleum hydrocarbons (diesel, gasoline, and waste oil), nitroaromatic and nitramine explosives, PETN, and PA.	Landfill was discovered on the east side of the excavation for the sewage lagoon during its construction in 1978. The draft EBS suggests the landfill was probably operated from 1940 to 1950.
Landfill 3	Household waste and debris, with possible military waste; could include solvents, paints, waste oil, petroleum products, pesticides, and ordnance.	Volatile and semivolatile organics, heavy metals, cyanide, PCBs, organochlorine pesticides, total petroleum hydrocarbons (diesel, gasoline, and waste oil), nitroaromatic and nitramine explosives, PETN, and PA.	Located southeast of the existing sewage lagoon. Reportedly used as a trash burial area during the late 1970s to early to mid-1980s. Soil was scraped from nearby and pushed onto the landfill, creating a broad mound above the landfill.
Burn Area	Burned waste, demolition debris, pesticides, waste oils, and ordnance.	Volatile and semivolatile organics, heavy metals, PCBs, organochlorine pesticides, total petroleum hydrocarbons (diesel, gasoline, and waste oil), nitroaromatic and nitramine explosives, PETN, and PA.	Located immediately north of Landfill 3, to the southeast of the existing sewage lagoon. This area reportedly was used infrequently to burn wood and unknown debris and has not been used since the mid-1980s. Unburned debris that reportedly had been piled there for three or four years was removed in early 1998.

TABLE 2-2 (CONT.)
SITE DESCRIPTIONS

Site	Potential Contaminant Source	Contaminants of Potential Concern	Site Description
Former Buildings 1962 and 1983	Lead-based paint, combustion residues, and asbestos-containing materials in roofing materials.	Lead, asbestos, and semivolatile organic compounds.	Located near the southeastern corner of the Bonneville cantonment. Building 1962 was a 9-foot-wide by 12-foot-long storage shed. Building 1983 was a 10-foot-wide by 40-foot-long structure. Both buildings were constructed in the 1930s. Both buildings were burned in place, and all burned debris was removed.
Drum Disposal Area	Leaking drums of liquid waste materials, particularly paints, solvents, pesticides, waste oils, and petroleum products.	Volatile and semivolatile organics, heavy metals, PCBs, organochlorine pesticides, total petroleum hydrocarbons (diesel, gasoline, and waste oil), nitroaromatic and nitramine explosives, PETN, and PA.	Location reported by an anonymous caller. Located south of the Killpack cantonment, east of the gravel road leading south from the main east-west roadway through the facility.
Paint and Solvent Disposal Area	Leaking drums or containers, or possible direct dumping of paint and solvents. Potential for pesticides, waste oils, and petroleum products.	Volatile and semivolatile organics, heavy metals, PCBs, organochlorine pesticides, total petroleum hydrocarbons (diesel, gasoline, and waste oil), nitroaromatic and nitramine explosives, PETN, and PA.	Location reported by an anonymous caller. Located south of the Killpack cantonment in an area near the existing tractor shed.
Maintenance Pit	Automotive wastes, including waste oil, antifreeze, and lubricants discharged or drained from vehicles during maintenance; could include disposal of solvents and pesticides.	Total petroleum hydrocarbons, heavy metals, volatile and semivolatile organics, PCBs, and organochlorine pesticides.	The pit was located beneath the concrete floor slab under the west end of Building 4775, in the Camp Killpack cantonment. The maintenance pit was an unlined excavation; the exact size, depth, and location were not documented. The site is bounded by Wash Rack No. 1 and a small stream to the west, a gravel drive and storage buildings to the north, and a ditch and the main road to the south. Pesticides reportedly were handled in the area in front of the building.
Wash Rack No. 1	Automotive wastes, including waste oil, gasoline, antifreeze, and lubricants, along with cleaning solvents discharged during washing activities or vehicle maintenance.	Total petroleum hydrocarbons, heavy metals, and volatile and semivolatile organics.	Located immediately west of Building 4775 in the Camp Killpack cantonment. The facility was reportedly in use between 1978 and 1994. The wooden wash rack structure remains in place.

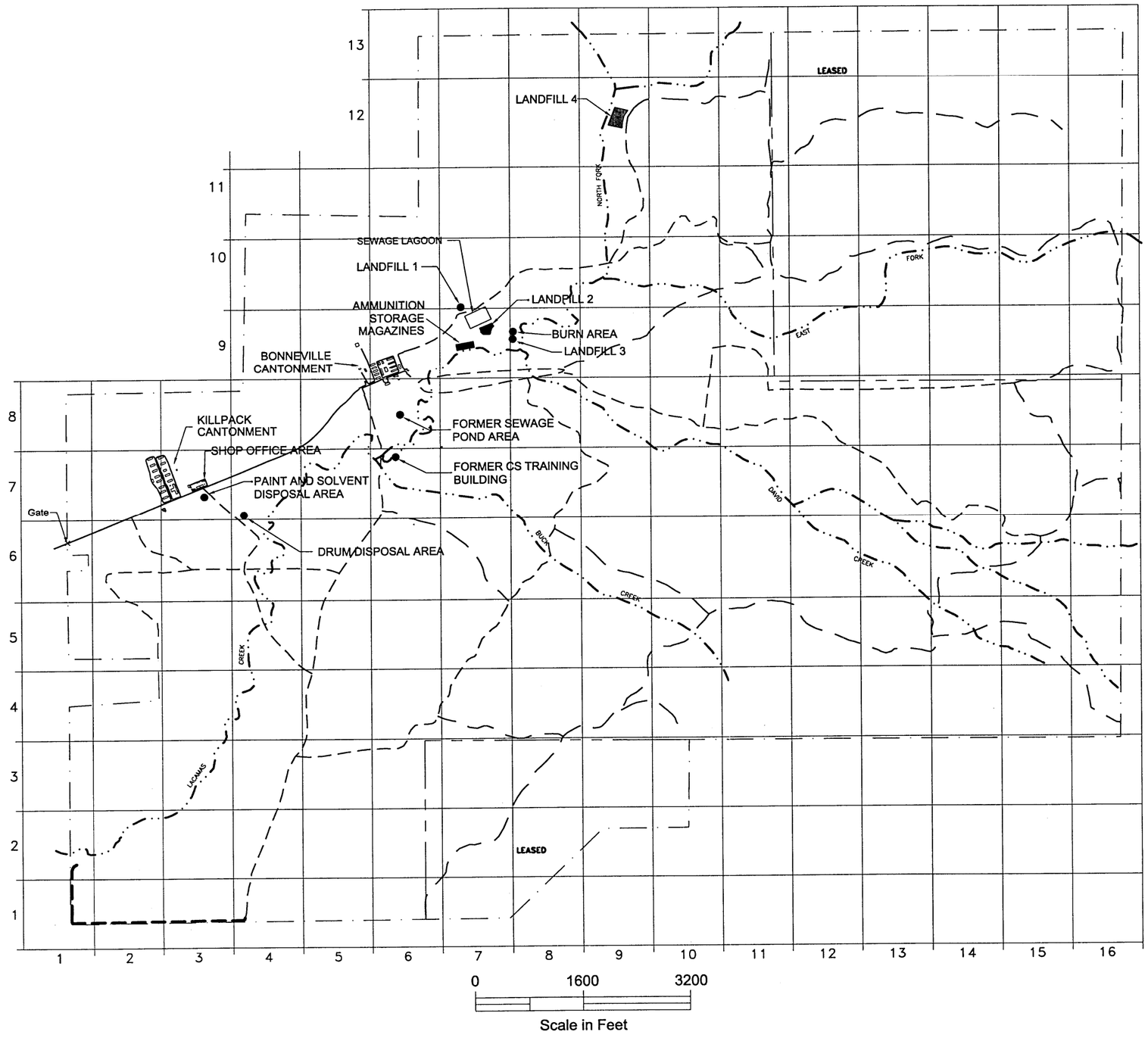
TABLE 2-2 (CONT.)
SITE DESCRIPTIONS

Site	Potential Contaminant Source	Contaminants of Potential Concern	Site Description
Grease Pits	Cooking greases and oils disposed of in the pits; could include unauthorized disposal of solvents, paints, and pesticides.	Total petroleum hydrocarbons, heavy metals, volatile and semivolatile organics, PCBs, and organochlorine pesticides.	Three grease pits have been identified: two in the Camp Bonneville cantonment north of Building 1828, and one in the Camp Killpack cantonment east of Building 4389. Each of the grease pits is gravel-filled and contains corrugated metal pipes that extend vertically into the gravel.
Pesticide Mixing/ Storage Building	Pesticides and herbicides of various types discharged to the dry well or spilled in front of the building; could include solvents, petroleum, and metals.	Total petroleum hydrocarbons, heavy metals, volatile and semivolatile organics, PCBs, organochlorine pesticides, organophosphorus pesticides, and chlorinated herbicides.	Identified as Building 1864, the Pesticide Mixing/Storage Building is located on the west side of the Camp Bonneville cantonment. The building was previously used for pesticide mixing and storage. It is currently used for storing equipment, vehicles, small gasoline containers, and batteries.
Aboveground Storage Tanks	Heating oil spilled during tank filling or discharged via leaks.	Total petroleum hydrocarbons.	There are 26 ASTs at the facility: 23 in the Camp Bonneville cantonment and 3 in the Camp Killpack cantonment. The ASTs were used to store heating oil and are approximately 275 gallons in size. They are located adjacent to the exteriors of individual buildings.
Former Sewage Pond	Sewage waste discharged to the pond during former use and UXO from more recent activities; could include metals, solvents, petroleum products, PCBs, and pesticides.	Total petroleum hydrocarbons, heavy metals, volatile and semivolatile organics, PCBs, organochlorine pesticides, bacterial pathogens (water), and cations/anions (water).	Located south of the Camp Bonneville cantonment. The site is located in the former parade ground area, north of Lacamas Creek. The exact location and dimensions of the pond were not documented.
Ammunition Storage Magazines	Explosives and metals residues from ammunition stored on site.	Metals plus barium, nitroaromatic and nitramine explosives, PETN, and PA	The three magazines are located east of the Camp Bonneville cantonment and southwest of the existing sewage lagoon. The magazines are designated Buildings 2950, 2951, and 2953. Each magazine is covered with a mound of soil.

TABLE 2-2 (CONT.)
SITE DESCRIPTIONS

Site	Potential Contaminant Source	Contaminants of Potential Concern	Site Description
Hazardous Material Accumulation Point	Spillage or leaks from drums of petroleum products, waste oil, antifreeze; could contain solvents and pesticides.	Total petroleum hydrocarbons, metals, volatile and semivolatile organics, PCBs, and organochlorine pesticides.	This site, also designated Building 4476, is located in the northeast corner of the shop area in the Camp Killpack cantonment. The structure is a three-walled cement masonry block building built in 1990. A sump is located in the middle of the structure's concrete floor.
Former CS Training Building	CS gas residues from releases in the building; cyanide as a byproduct of CS decomposition; lead-based paint; residues from building materials and their combustion; UXO from nearby activities.	CS (2-chlorobenzylidenemalononitrile) and its breakdown products (malononitrile and 2-chlorobenzaldehyde), cyanide, lead, and semivolatile organics.	Located south of the Camp Bonneville cantonment area, between Lacamas Creek on the north and the 50-caliber firing range on the south. The building was destroyed by fire sometime in the late 1970s. The exact dimensions of the building are unknown.
Wash Rack No. 2	Automotive wastes, including waste oil, gasoline, antifreeze, and lubricants, along with cleaning solvents discharged during vehicle maintenance or washing activities.	Total petroleum hydrocarbons, metals, and volatile and semivolatile organics.	Located in the Camp Killpack cantonment area at the northeast corner of the shop office area, behind Building 4476. This site has been described as both a vehicle wash rack and a vehicle maintenance rack. No structures remain at this site.
Landfill 4	Building demolition debris wastes with possible military waste buried on site; could include solvents, paints, petroleum products, pesticides, PCBs, and ordnance.	Volatile and semivolatile organics, heavy metals, PCBs, organochlorine pesticides, total petroleum hydrocarbons, nitroaromatic and nitramine explosives, PETN, PA, and cations/anions (water).	Located approximately 5,000 feet northeast of the Camp Bonneville cantonment. The site is in a clearing on a wooded hillside, underlying Ordnance Demolition Area 1. The site was reportedly used for the disposal of building demolition debris during the mid-1960s.

Notes:
ASTs = aboveground storage tanks
CS = 2-chlorobenzylidenemalononitrile (tear gas)
EBS = Environmental Baseline Survey
PA = picric acid
PCBs = polychlorinated biphenyls
PETN = pentaerythnol tetranitrate
UXO = unexploded ordnance



LEGEND

- INSTALLATION PROPERTY BOUNDARY
- LEASED AREAS BOUNDARY
- ALL WEATHER, HARD SURFACE, ASPHALT ROAD
- ALL WEATHER, LOOSE SURFACE, GRAVEL ROAD
- FAIR WEATHER, LOOSE SURFACE, EARTHEN ROAD
- CREEKS

Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

SITE LOCATION MAP

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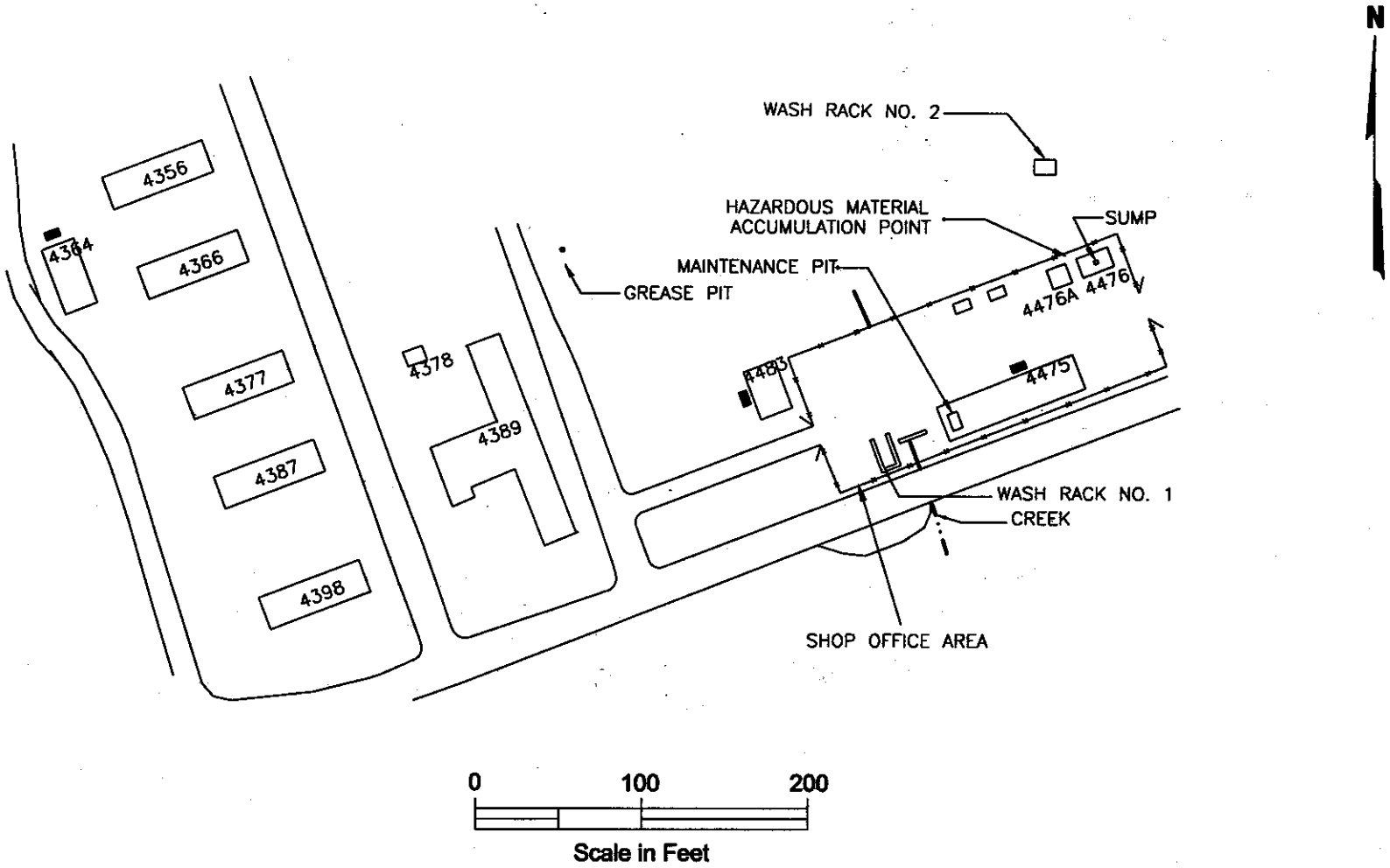
FIG. 2-1



LEGEND

FENCE

CREEK

ABOVE GROUND STORAGE TANK

Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

KILLPACK CANTONMENT AREA
SITE LOCATION MAP

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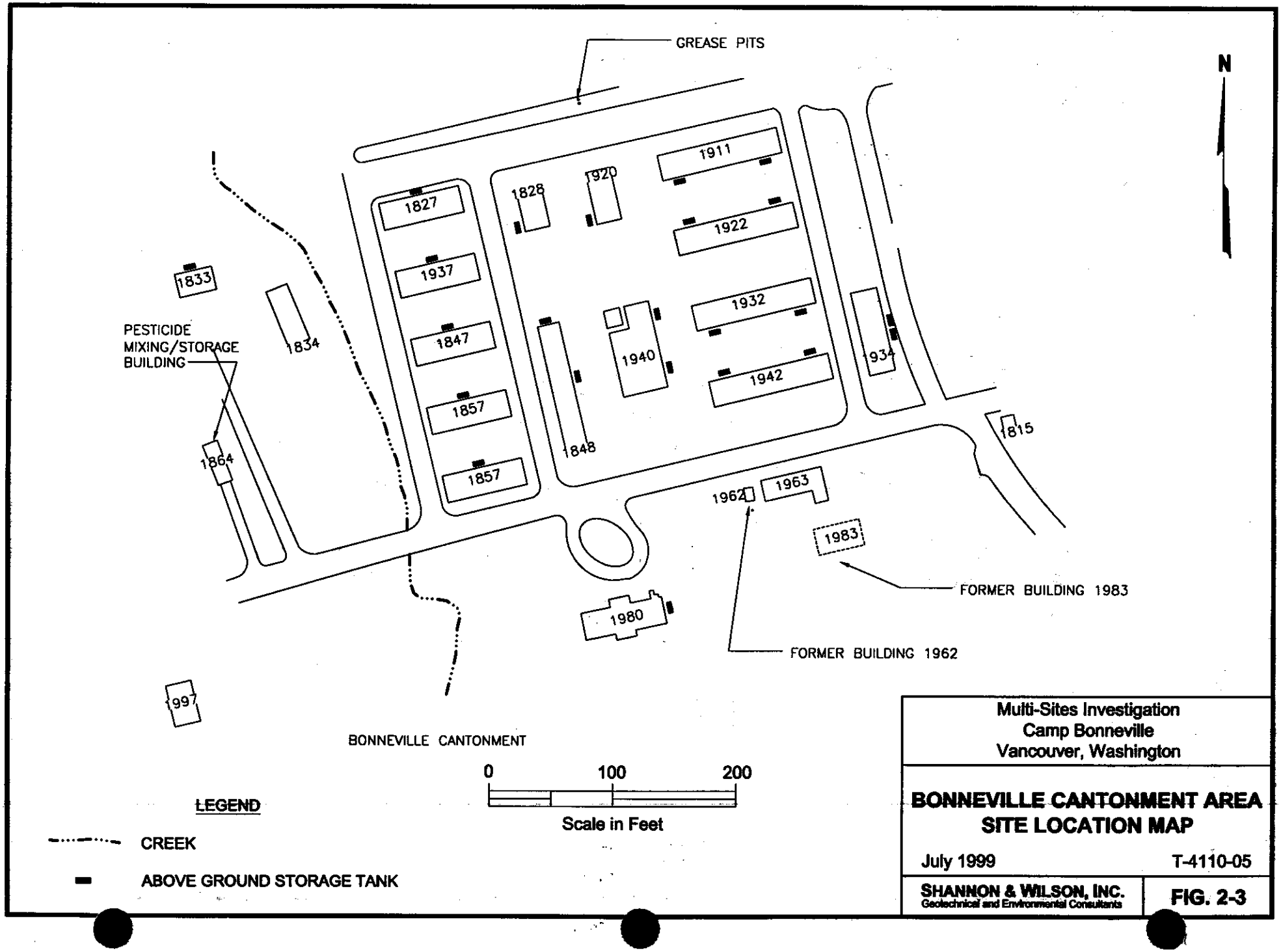
FIG. 2-2



Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

BONNEVILLE CANTONMENT AREA
SITE LOCATION MAP

July 1999 T-4110-05

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FIG. 2-3

3.0 ENVIRONMENTAL SETTING AND CONCEPTUAL SITE MODEL

3.1 LOCATION AND PHYSIOGRAPHY

Camp Bonneville is located in the Lacamas Creek valley in the western foothills of the Cascade Mountain Range. The area surrounding the camp is sparsely populated with scattered residences and is used primarily for agriculture and livestock grazing. The nearest town is Proebstel, an unincorporated community about two and one-half miles to the southwest of the western entrance to the camp.

The two cantonments, Camp Killpack and Camp Bonneville, are located on the valley floor. The remainder of the property consists of moderately steep, heavily vegetated slopes that have been used for military training. The valley floor is a relatively narrow floodplain, which ranges from an elevation of about 290 feet above sea level on the western end of the property to about 360 feet on the east. The adjoining slopes rise moderately steeply to elevations of between 1,000 and 1,500 feet along ridge tops within the property boundaries.

Lacamas Creek flows southwestward from the confluence of North Fork and East Fork in the north-central part of Camp Bonneville, to the southwestern corner of the property. It is fed by David Creek and Buck Creek, which drain the southeastern part of the property. From the southwestern property boundary, Lacamas Creek flows southwestward to Proebstel, where it turns toward the southeast and continues to its confluence with the Columbia River at the town of Camas.

The cantonments are accessible by a paved roadway through the western entrance of Camp Bonneville. Access within the camp is limited to a few all-season gravel roads, most of which are on the valley floor, and dirt roads leading into perimeter areas in the northern, southern, and western portions of the facility. Access to the camp is restricted to military personnel and others on official business. Because of the hazards associated with UXO, access to the facility outside of the containment areas is not allowed without an escort trained in ordnance recognition and avoidance.

3.2 CLIMATE

The Camp Bonneville area has mild, wet winters and moderately warm, dry summers. January is the coldest month, with an average temperature of about 38 degrees Fahrenheit (°F). July and August are the warmest months, with an average temperature of about 69° F. On the average, only 26 days a year experience temperatures below freezing, and 7 days have temperatures of 90°F. or more.

Most of the precipitation in the area is caused by the passage of low-pressure zones along a path from the north Pacific Ocean eastward over the state during the winter and spring. The rainy

season usually begins in the later part of September or in October, and continues through March or April. An average of 154 days a year have measurable amounts of rainfall, with an average annual precipitation of approximately 47 inches. Annual snowfall in the Vancouver area averages about 8.4 inches. The average snow depth is typically only 2 or 3 inches, with continuous snow cover lasting one to three days at a time. Heavy fog occurs frequently during the fall and winter.

3.3 GEOLOGY

Camp Bonneville is situated along the structural and physiographic boundary between the western flank of the southern Cascade Mountains and the Portland-Vancouver Basin. The geology of the Camp Bonneville vicinity is known primarily from geologic mapping by Mundorff (1964) and Phillips (1987), from a limited number of well logs available from the general area, and from borings drilled for this investigation. As shown in Figure 3-1, four distinctive stratigraphic units underlie the camp area:

- Quaternary floodplain and stream channel alluvium and lacustrine deposits, which mantle the Lacamas Creek valley floor (Qa).
- A Quaternary landslide deposit (Qls) formed in bedrock on the steep slope along David Creek.
- A thick sequence of Quaternary to Pliocene-age gravel, fine-grained sand, and cobbly and bouldery sand known as the Troutdale Formation (Pt), which underlies areas to the west of the Bonneville cantonment.
- Oligocene-age volcanic bedrock (Tv), which is exposed at the surface in the eastern part of the Camp.

The alluvium underlying the Lacamas Creek valley floor was deposited in Quaternary time as stream channel, floodplain, and alluvial fan sediments. This type of deposit typically varies significantly in grain size, both laterally and vertically, depending on localized depositional environments. In the soil borings drilled for this investigation, these deposits are comprised primarily of clay and silt near the surface, frequently with a thin layer of silty sand and gravel encountered at depths ranging from 3 feet below ground surface (bgs) (in part of the Landfill 2 and 3 area) to 17 feet bgs (in the Pesticide Mixing/Storage Building area). These coarser-grained materials are underlain either by weathered volcanic rock or by finer-grained silts and clays above weathered rock. The stratigraphy was observed to vary considerably within some site areas (in multiple borings drilled at a site), as well as between sites. For example, in the Landfill 2 and 3 area the soil thickness above weathered volcanic rock varied from about 7 to 29 feet bgs, and the depth to sand/gravel ranged from 3 to 7.5 feet bgs (where present). Eighteen feet of silty clay was encountered underlying the sand/gravel in one of the landfill borings, while other borings indicated the presence of significantly less or no underlying clay (above weathered rock). These clayey soils probably originated as slack water deposits that were laid down on the valley

floor in Quaternary time as a result of catastrophic flooding along the Columbia River. The stratigraphy encountered at each site where drilling was performed is described further, by site, in Section 6.

Phillips (1987) mapped a large landslide deposit on the steep northwest-facing slope of Lacamas Creek above the Camp Bonneville cantonment. The age of the landslide is not known, although its topographic expression suggests that it is ancient. The slide involved displacement of surface soils and bedrock over about 100 acres of land adjoining David Creek. The landslide deposits extended from an elevation of about 1,000 feet at the headwall of the slide to an elevation of about 500 feet at its toe along David Creek.

The Troutdale Formation, which reportedly underlies a portion of the western part of the camp, ranges from a poorly consolidated sand and gravel to a well-indurated conglomerate in its upper part. Based on logs from nearby wells, the upper Troutdale Formation is locally about 150 feet thick and consists of sand, gravel, sandy clay, and boulders. It is underlain by up to 150 feet of lower Troutdale Formation, which contains considerably more clay interspersed with sandy and gravelly layers. There is considerable variation in the lithology and thickness of the Troutdale Formation. In general, the formation thins eastward against the underlying bedrock, and the lower part of the formation reportedly is typically coarser grained toward the east (Mundorff, 1964). Evidence of the Troutdale Formation was not encountered during this investigation.

The bedrock underlying the alluvial and lacustrine deposits (and Troutdale Formation, where present), and exposed at the surface in the eastern part of the Camp, consists of Oligocene-age andesite and basaltic andesite flows, minor flow breccias, pyroclastics, and tuffs, with some interbedded sedimentary rocks. Andesite is the most common volcanic rock in the area. It generally ranges from medium to very fine grained, is commonly porphyritic, and is medium to brownish gray. Based on borings drilled for this study, the uppermost bedrock is typically severely weathered. During drilling for this investigation, bedrock was encountered in 10 soil borings, at depths ranging from approximately 6 feet bgs at the Ammunition Storage Magazine site to 37 feet bgs at the Pesticide Mixing/Storage Building site.

Information on the deeper lithology in the Camp Bonneville area was obtained from well logs maintained by Ecology. Well logs from areas adjacent to the western portion of Camp Bonneville (including the areas northwest and southwest of the facility) were reviewed to obtain information on the surrounding geology. The reported depth to rock is highly variable, ranging from near the ground surface to more than 200 feet bgs. Considerable thicknesses of clay and gravel are reported in some areas, such as along the Lacamas Creek Floodplain south of the facility. Rock is typically encountered at shallow depths in areas along the flanks of the hills and at higher elevations.

Two well logs were available for wells drilled on Camp Bonneville property. (Copies of the well logs are included in Appendix D.) In 1978, a well was drilled in the Camp Bonneville cantonment area to a depth of approximately 370 feet bgs. The lithology is generally described as clay and gravel, with some sand, to 133 feet bgs. Weathered rock, with some clay, was

encountered from 133 to 207 feet bgs, at which depth the rock (basalt) became hard. Another zone of soft, weathered basalt was identified from about 304 to 334 feet bgs. In April 1998, a well was drilled at the FBI range to a total depth of 105 feet bgs. The well log for this well describes the lithology encountered as brown clay to 15 feet bgs, clay and gravel from 15 to 30 feet bgs, brown clay from 30 to 55 feet bgs, and rock from 55 to 105 feet bgs, the total depth of the boring. Information on a third well drilled at Camp Bonneville was obtained from Mundorff (1964). Because the drilling was done to deepen an existing 125-foot-deep well, no lithologic information was available from the land surface to 125 feet bgs. The remaining lithology is described as clay and gravel from 125 to 200 feet bgs, gravel from 200 to 290 feet bgs, and volcanic rock (lava) from 290 to 516 feet bgs.

3.4 HYDROGEOLOGY

Based on a review of well logs from limited areas immediately south, west, and north of the facility, the majority of the wells appear to draw groundwater from volcanic rock. The volcanic rock typically is a poor aquifer. At places the rock is weathered to depths of several tens of feet, and a considerable volume of water may be stored in the saturated subsoil (Mundorff, 1964). Wells drilled into the unweathered rock typically yield only enough water for limited domestic use. In some cases, groundwater may be obtained from the vesicular, broken, and brecciated upper part of an individual lava flow, immediately beneath the base of the overlying flow. Screened intervals in nearby wells vary widely, ranging from depths of less that 50 feet bgs to more than 400 feet bgs, but more commonly falling between about 100 to 250 feet bgs. In many cases, significant thicknesses of clay have been identified overlying the rock; however, the depth to rock and clay thickness are highly variable.

A few shallow wells (roughly 50 feet bgs) are present in the site area, some of which draw water from unconsolidated materials. In general, these wells appear to tap only thin layers of coarser-grained materials and do not yield large volumes of water.

At least three deep wells have been drilled on Camp Bonneville property for potable water supply: one at the Camp Bonneville cantonment, one at the Camp Killpack cantonment, and one at the FBI range. The two older wells have been described as a 385-foot-deep well at the Camp Bonneville cantonment and a 193-foot-deep well at the Camp Killpack cantonment (Woodward-Clyde, 1996). However, a well log for a well installed at the Camp Bonneville cantonment in 1978 indicates a depth of 364 feet (with a screened interval of 250 to 364 feet bgs), and published information (Mundorff, 1964) indicates the presence of a 516-foot-deep well at the Camp Killpack cantonment. It is not clear if these are the same Camp Bonneville and Camp Killpack cantonment wells. The water level at the time the Camp Bonneville cantonment well was installed was 4.8 feet below the top of casing (see log in Appendix D). The information on the Camp Killpack well indicates that it originally extended to a depth of 125 feet bgs, but was subsequently deepened. A water level of 126 feet bgs was recorded in this well during July 1943 (Mundorff, 1964). The FBI range well was installed in April 1998. The well log for this well indicates that it is screened from 65 to 105 feet bgs (see log in Appendix D). The water level at

the time the well was installed was 23 feet below the top of casing. The two cantonment wells are described as being screened in volcanic rock (lava rock or basalt). The FBI well is described only as being screened in rock.

Monitoring wells were installed at four sites at Camp Bonneville during this investigation: Landfill 2, Landfill 3, the Pesticide Mixing/Storage Building, and the Former Sewage Pond. Additional wells installed at the Landfill 4 site will be described in a separate report. The source areas investigated were located at the ground surface or at shallow depths; therefore, shallow monitoring wells were installed.

Shallow groundwater appears to generally conform to site topography. The water table is typically within a few feet of the surface in the area underlain by alluvium. Iron staining observed in the soil profile above the water table provides an indication that the groundwater beneath the valley floor is very near the ground surface during the rainy season. The water table aquifer appears to fluctuate a few feet in depth, rising in the fall through spring during the rainy season, and falling during the drier summer months. Two rounds of water level measurements were made in the monitoring wells installed during this investigation; one in August and one in December 1998. Water level increases ranged from about 0.5 to 2.5 feet between the two measurements. Fluctuations observed in individual wells are described in Section 6.

In humid or subhumid areas, such as the Camp Bonneville area, groundwater typically discharges to streams and lakes, and the lowest points on the water table are at these places. Precipitation falling on the land surface either runs off at the surface or percolates downward to recharge shallow groundwater. Ponded water occurs at the land surface during the wet season at most of the sites investigated because of the low permeability of the shallow soils. Therefore, surface runoff at the sites can be relatively high. Once water has reached the water table, it tends to move laterally downgradient toward discharge points at rivers, lakes, or wetlands. Rivers or creeks contribute to groundwater recharge only temporarily during periods of flooding. In humid regions, the water table typically reflects the topography, with somewhat less relief. Therefore, shallow groundwater at the sites investigated is assumed to discharge to adjacent surface water bodies, such as Lacamas Creek and its tributaries.

The yield of the surficial deposits is dependent on the permeability of the soil. Zones of sand and gravel have relatively high yields, whereas the clayey soils have very low yields. Where clay is present, it generally provides a barrier to groundwater movement. This condition was noted at a UST site in the Killpack cantonment (Hart Crowser, 1996), although the clay in this location was observed to contain fine, discontinuous seams of sand that transmit groundwater for short distances (Corps, 1997c). Shallow silty and clayey layers impede groundwater infiltration and can cause shallow perched zones with water levels that rise rapidly during high rainfall periods. A perched aquifer (shallow saturated soils overlying less permeable, unsaturated materials) was observed at all of the sites where monitoring wells were installed during this investigation. Groundwater was found to be perched over either clay or the highly weathered surface of volcanic rock at these sites. Some of these perched zones may be seasonal,

disappearing during the drier summer months (such as at the upgradient well location at Landfill 2). Others remain saturated and flow toward nearby surface drainage features.

At the Landfill 2 and 3 sites, the thickness and presence of clay underlying the perched groundwater appears to be highly variable, with 0 to 18 feet of unsaturated clay observed between the saturated zone and highly weathered rock. At the Former Sewage Pond site, the saturated zone is underlain by unsaturated, highly weathered volcanic rock. At the Pesticide Mixing/Storage Building, silty clay was present between the saturated zone and the weathered rock surface. This clay was about 9 feet thick in the upgradient well location, and of an unknown thickness in the downgradient location.

3.5 CONCEPTUAL SITE MODEL

A conceptual site model (CSM) defines the exposure pathways for a site. A complete exposure pathway must exist before any risk to human or ecological receptors is possible. The components of an exposure pathway include (1) primary contaminant source(s) and release mechanisms; (2) secondary sources; (3) mechanisms of contaminant retention in, or transport to, exposure media; (4) receptors that may contact contaminants in exposure medial; and (5) routes of intake of contaminated media by receptors. If any one of these elements is missing, a given exposure pathway is incomplete. Table 3-1 provides a summary of the potential contaminant sources and migration pathways for each of the 17 sites investigated. A summary of the potential sources, release mechanisms, and receptors is provided in Figure 3-2.

3.5.1 Primary Sources and Release Mechanisms

The release mechanisms include spills or other releases from aboveground and belowground sources. The aboveground sources include the following:

- Hazardous materials in material storage and handling areas (Ammunition Storage Magazines and Hazardous Material Accumulation Point)
- Pesticides in mixing and application areas (Pesticide Mixing and Storage Building and in front of the Maintenance Pit)
- Burned buildings and other burned materials (Former Burn Area, Former Buildings 1962 and 1983, and Former CS Training Building)
- Aboveground fuel storage tanks (in the Killpack and Bonneville cantonment areas)
- Vehicle maintenance areas (Wash Rack Nos. 1 and 2)

The belowground sources include the following:

- Landfills and other debris burial sites (Landfills 1, 2, and 3; Drum Disposal Area; and Paint and Solvent Disposal Area)

- Belowground vehicle maintenance areas (Maintenance Pit)
- Belowground waste disposal areas (Grease Pits, dry well at the Pesticide Mixing/Storage Building, and Former Sewage Pond)

Several of the belowground sources may release contaminants directly into shallow groundwater that is in contact with the source materials.

3.5.2 Secondary Sources

In addition to serving as a direct exposure medium, soils are a secondary source from which chemicals may potentially be released to other media such as groundwater. Groundwater may also serve as a secondary source from which chemicals may be released to other media such as surface water.

3.5.3 Mechanisms of Retention in or Transport to Exposure Media

The mechanisms of retention, transfer, or transport of site chemicals are based on the general geology and hydrogeology of the site, and chemical properties of the contaminants. Soil is a retention medium at the site and a potential secondary source from which chemicals may migrate to other media. Infiltrating rainwater may dissolve chemicals, resulting in their transfer from soils downward to groundwater. In addition, contaminants in surface soil may migrate via surface runoff to nearby streams and creeks. If site-related chemicals are present in groundwater, they may be subsequently transported via groundwater flow to nearby streams and creeks.

At this time, air (volatilization) is not included as a migration pathway because most of the contaminants of concern are non-volatile compounds, and many of the releases occurred belowground. In addition, most of the releases occurred many years ago, so volatile constituents at or near the surface would have volatilized already.

3.5.4 Receptors and Exposure Routes

There are no permanent residents at Camp Bonneville. Although the facility is not currently open to site visitors or recreational users, future use plans may allow such activities; therefore, site visitors are included as potential human receptors. Site workers are present occasionally at the sites at this time and may be present more frequently in the future. Site workers could be exposed to affected subsurface soil and groundwater during excavation activities at the site. Terrestrial and aquatic biota are present in the site area and therefore may be receptors.

Potential exposure routes include ingestion of affected media and dermal contact with affected media. In the case of affected surface water or sediments, ingestion of fish from the neighboring creeks would be another potential exposure route. Additional discussion of the CSMs for each of the sites investigated are provided in Section 6, following the discussion of findings at each site. Specifically, included is a discussion of complete and significant pathways based on subsurface findings and analytical results.

TABLE 3-1
CONTAMINANT SOURCES AND MIGRATION PATHWAYS

Site	Potential Contaminant Sources	Migration Pathways - Soil	Migration Pathways - Groundwater	Migration Pathways – Surface Water
Landfill 1	Discharges from buried household debris.	Contaminants could be discharged directly to subsurface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via groundwater.
Landfill 2	Discharges from buried military waste and debris of unknown composition.	Contaminants could be discharged directly to subsurface soil.	Due to the shallow water table at this site, contaminants could enter groundwater directly or via migration through soil.	Contaminants could migrate to surface water via groundwater. Potentially affected surface water bodies include Lacamas Creek, located approximately 200 feet from the site.
Landfill 3	Discharges from buried household waste and debris with potential military waste.	Contaminants could be discharged directly to subsurface soil.	Due to the shallow water table at this site, contaminants could enter groundwater directly or via migration through soil.	Contaminants could migrate to surface water via groundwater. Potentially affected surface water bodies include Lacamas Creek, located adjacent to the site.
Former Burn Area	Aboveground debris storage and burning.	Contaminants could be discharged directly to surface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include Lacamas Creek, located approximately 50 feet from the site.
Former Buildings 1962 and 1983	Burned building (aboveground).	Contaminants could be discharged directly to surface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include Lacamas Creek, approximately 400 feet south of the site.

TABLE 3-1 (cont.)
CONTAMINANT SOURCES AND MIGRATION PATHWAYS

Site	Potential Contaminant Sources	Migration Pathways - Soil	Migration Pathways - Groundwater	Migration Pathways – Surface Water
Drum Disposal Area	Discharges from buried drums of liquid wastes.	Contaminants could be discharged directly to subsurface soil.	Due to the shallow water table at this site, contaminants could enter groundwater directly or via migration through soil.	Contaminants could migrate to surface water via groundwater. Potentially affected surface water bodies include Lacamas Creek, located approximately 400 feet southeast of the site.
Paint and Solvent Disposal Area	Discharges from buried and partially exposed drums and containers of liquid wastes.	Contaminants could be discharged directly to surface and subsurface soil.	Due to the shallow water table at this site, contaminants could enter groundwater directly or via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include a small stream to the west of the site.
Maintenance Pit	Discharges from in-ground vehicle maintenance activities and spills from aboveground pesticide handling.	Contaminants could be discharged directly to surface and subsurface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include the small stream immediately west of the site.
Wash Rack No. 1	Discharges from aboveground vehicle maintenance activities.	Contaminants could be discharged directly to surface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include the small stream immediately east of the site.
Grease Pits	In-ground disposal of cooking grease with possible other fluids.	Contaminants could be discharged directly to subsurface soil.	Contaminants could enter groundwater via migration through soil or by direct discharge.	Contaminants could migrate to surface water via groundwater. Potentially affected surface water bodies include a small stream located east of the Killpack grease pit.

TABLE 3-1 (cont.)
CONTAMINANT SOURCES AND MIGRATION PATHWAYS

Site	Potential Contaminant Sources	Migration Pathways - Soil	Migration Pathways - Groundwater	Migration Pathways – Surface Water
Pesticide Mixing/Storage Building	Aboveground pesticide handling and in-ground waste disposal.	Contaminants could be discharged directly to surface and subsurface soil.	Contaminants could enter groundwater via migration through soil or by direct discharge.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include the small drainage east of the site.
Aboveground Storage Tanks	Spill and leaks from aboveground fuel storage.	Contaminants could be discharged directly to surface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include various small drainages.
Former Sewage Pond	Discharges from in-ground sewage disposal.	Contaminants could be discharged directly to subsurface soil.	Due to the shallow water table at this site, contaminants could enter groundwater directly or via migration through soil.	Contaminants could migrate to surface water via groundwater. Potentially affected surface water bodies include Lacamas Creek, located approximately 200 feet southeast of the site.
Ammunition Storage Magazines	Spills from aboveground ammunition storage and handling.	Contaminants could be discharged directly to surface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include Lacamas Creek, located just south of the site.
Hazardous Material Accumulation Point	Spills and leaks from drum storage and handling.	Contaminants could be discharged directly to surface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include the small stream approximately 120 feet west of the site.

TABLE 3-1 (cont.)
CONTAMINANT SOURCES AND MIGRATION PATHWAYS

Site	Potential Contaminant Sources	Migration Pathways - Soil	Migration Pathways - Groundwater	Migration Pathways – Surface Water
Former CS Training Building	Burning and burial of building debris.	Contaminants could be discharged directly to surface and subsurface soil.	Contaminants could enter groundwater via migration through soil or by direct discharge.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include Lacamas Creek, located immediately north of the site.
Wash Rack No. 2	Discharges from aboveground vehicle maintenance activities.	Contaminants could be discharged directly to surface soil.	Contaminants could enter groundwater via migration through soil.	Contaminants could migrate to surface water via surface runoff and via groundwater. Potentially affected surface water bodies include the small stream approximately 120 feet west of the site.

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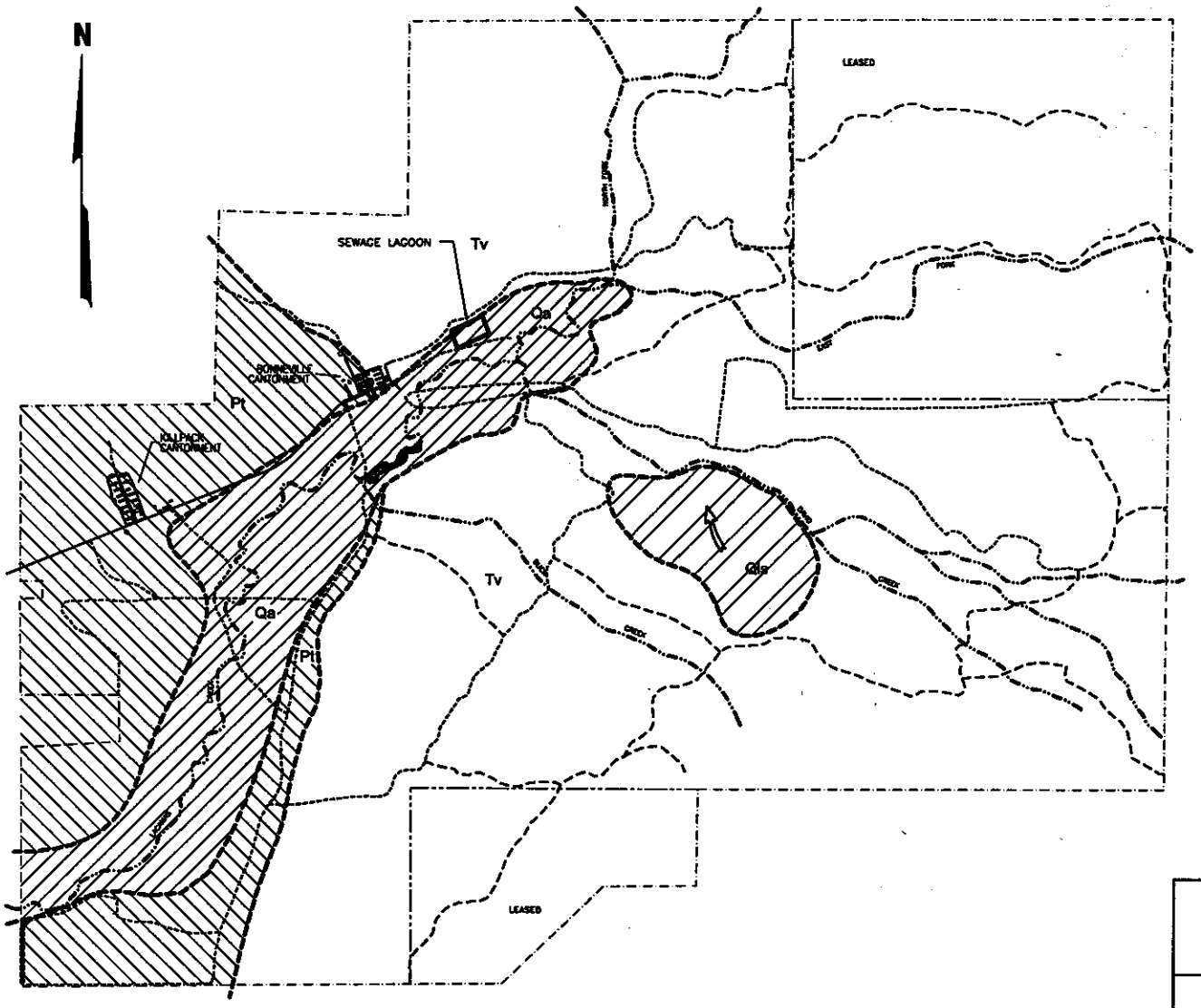


KEY TO GEOLOGIC FORMATIONS

Qa Alluvium; floodplain and stream channel deposits of silt, clay, sand, and gravel.

Qls Quaternary Landslide Deposit. Arrow indicates direction of movement.

Pt Troutdale Formation: Upper member consists predominantly of cemented sandy gravel with pebbles and cobbles; lower member consists predominantly of fine sand, silt, and clay.

Tv Tertiary Volcanics: Basalt and andesite lava flows, with some pyroclastics, tuff, shale, and agglomerate.

LEGEND

- INSTALLATION PROPERTY BOUNDARY
- LEASED AREAS BOUNDARY
- ALL WEATHER, HARD SURFACE, ASPHALT ROAD
- ALL WEATHER, LOOSE SURFACE, GRAVEL ROAD
- FAIR WEATHER, LOOSE SURFACE, EARTHEN ROAD
- CREEKS

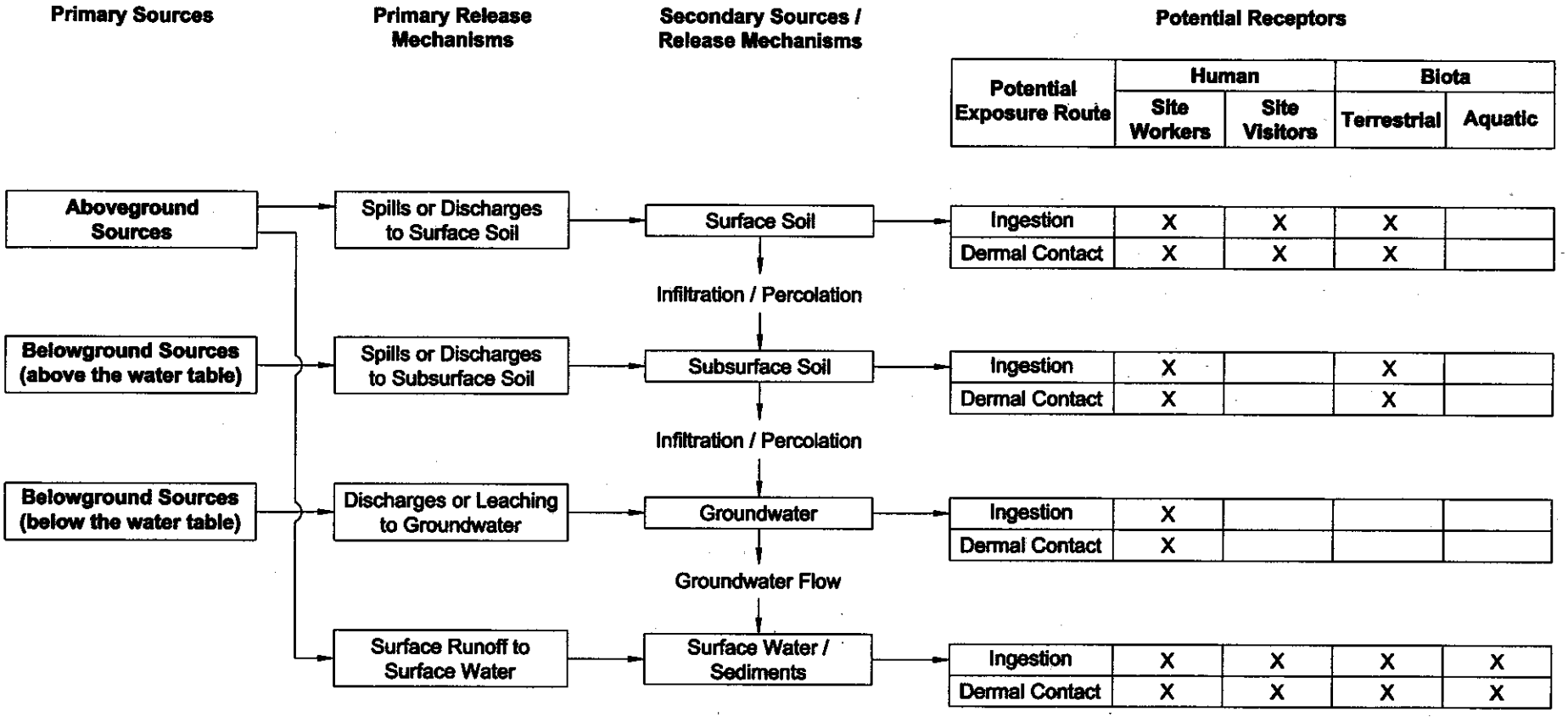
Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

GEOLOGIC MAP OF CAMP BONNEVILLE

July 1999 T-4110-05

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 3-1



NOTE

See Table 3-1 for site-specific information.

Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

CONCEPTUAL SITE MODEL

July 1999 T-4110-05

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FIG. 3-2

4.0 INVESTIGATION METHODS

4.1 INVESTIGATION PHASES

Tasks performed during the site investigations included initial UXO avoidance work, geophysical surveys, soil gas surveys, and sampling activities, including collection of surface and subsurface soil, groundwater, and wipe samples. A summary of the tasks performed at each site is presented in Table 4-1.

The investigations of the 17 sites described in this report were performed in three separate phases of work: Phase 1 was performed from December 8 to 18, 1997; Phase 2 was performed from February 25 through March 4, 1998; and Phase 3 was performed from July 8 through August 6, 1998. The phased approach accommodated both site accessibility and three separate contracts awarded at different times and with different schedules.

Phase 1 of the field investigation included preliminary work at the Multi-Sites I sites and occurred following approval of the Multi-Sites I Management Plan. The second phase of the investigation was planned to follow after receipt and evaluation of the Phase 1 data, but it was delayed until the Multi-Sites II Management Plan was approved so that the work could be performed concurrently. Because of excessively wet site conditions, activities requiring the use of a drilling rig were delayed until site access conditions improved. Therefore, the Phase 2 investigation included only hand-sampling activities at both Multi-Sites I and II sites. Phase 3 of the investigation was accomplished after site conditions had improved and access by a drilling rig was possible. This phase included the remaining work at the Multi-Sites I and II sites, as well as additional investigation specified in the Multi-Sites III Management Plan. The tasks performed during each phase of the investigation are indicated on Table 4-1.

The Landfill 4 investigation was further delayed because of UXO concerns. Investigation of this site took place during the winter of 1998-99 (Phase 4). Results of the Landfill 4 investigation will be described in a separate report.

4.2 SCOPE OF FIELD INVESTIGATIONS

The field investigation methods are discussed briefly in the following subsections. Detailed descriptions of these methods are provided in the project Management Plans (Shannon & Wilson, 1997; 1998a; and 1998b). Further discussion of the tasks performed at each site is provided in Section 6.

A description of the sample numbering system is provided in Table 4-2. Included are the sample location identification codes used and the sample type codes.

4.2.1 UXO Avoidance

Because Camp Bonneville has been used for nearly 80 years as a military firing range, there is a potential that UXO exists on or near several of the sites included in this investigation. Therefore, UXO avoidance measures were completed at selected sites before other workers were allowed to begin their site activities. Sites at which UXO avoidance work was performed included the landfills, Former Burn Area, Drum Disposal Area, Paint and Solvent Disposal Area, Former Sewage Pond, and Former CS Training Building.

ECC provided a team of UXO specialists who performed UXO avoidance activities at the designated sites, including (1) visual inspection, (2) magnetometer surface surveys for foot or vehicular traverses off from established roadways and walkways, and (3) downhole magnetometer checks where intrusive subsurface explorations took place. The work was accomplished strictly for avoidance of UXO; removal or disarming of UXO was not accomplished as part of this work.

During the surface surveys, locations where surface magnetometer readings indicated the presence of metal were marked with a yellow flag. These areas were avoided during subsequent work at the site. No UXO was identified during the investigations (except a LAW round that was found near Landfill 2 during an initial reconnaissance). However, a large amount of metallic surface debris was encountered, including pipes, fence posts, wire, vehicle parts, drums, and other materials. Some of this debris was buried at shallow depths; therefore, the sources of the magnetometer readings frequently were not known. In addition, the high metallic content of natural rocks in the area caused elevated readings from the magnetometers.

At each soil boring location, the UXO specialists initially performed surface UXO avoidance procedures. The UXO team then hand augered each borehole to a depth of 2 feet bgs and lowered a downhole magnetometer into the borehole to confirm the absence of magnetic anomalies. If an anomaly was found, the boring was relocated to avoid possible buried ordnance. If no anomalies were found, the UXO personnel hand augered another 2 feet and again checked the borehole using the downhole magnetometer. These UXO avoidance procedures continued every 2 feet until natural ground was reached, or to a depth of approximately 5 feet (a conservatively estimated potential depth of UXO penetration in areas where drilling started at natural ground), at which time drilling proceeded without further UXO surveys.

During performance of the investigation, the field work was modified to avoid yellow flagged areas and to drill and collect subsurface soil samples from areas without a significant surficial magnetic response. In addition, borehole locations were moved if significant downhole magnetic responses were obtained.

4.2.2 Geophysical Surveys

The perimeters of buried materials at selected sites were determined by performing geophysical surveys using electromagnetic (EM) equipment and ground penetrating radar (GPR). Sites at which geophysical surveys were performed include the landfills, Drum Disposal Area, Paint and Solvent Disposal Area, and Former Sewage Pond. EM was the primary method used. Although extensive use of GPR was planned, the naturally high conductivity of the site soils and soil water content limited the effective depth of penetration. In addition, the irregular land surface and thick vegetation encountered at most of the sites was more readily accommodated by EM equipment.

Before each geophysical survey was conducted, the UXO team performed UXO avoidance activities at the site and marked safe boundaries. The equipment was calibrated as described in the Management Plans. A base line was established at each site using a rope chain marked at 10-foot intervals. Survey traverse lines at approximately 10-foot intervals were laid out from the base line with a right-angle prism. A rope chain, marked at 10-foot intervals, was laid along the traverse line to establish data point locations (and horizontal distances on the GPR record). The approximate limits of the disposal site boundaries, as determined using the geophysical methods, were marked with wood stakes and red flagging in the field. These points were later surveyed. Reports describing the methods and findings, including contour maps of the conductivity data and GPR records, are provided in Appendix B.

4.2.3 Soil Gas Surveys

Soil gas surveys were performed in the Landfill 2 and 3 areas, following UXO avoidance surveys and geophysical surveys, in an attempt to identify volatile organic compounds (VOCs) of concern associated with the landfills. The surveys were performed by TEG of Lacey, Washington. A grid was laid out over the surface of each landfill, using a 20-foot spacing. Perimeter samples were also collected approximately 10 to 20 feet outside of the landfill boundaries as determined by the geophysical surveys. Sampling locations were adjusted as necessary to avoid areas where the UXO specialists detected buried metal. Approximate soil gas sample locations are indicated in figures included in Appendix B.

The samples were collected using the Vaportek Passive Soil Vapor Technique. Holes were punched to a depth of 18 inches using a hand sampling tool. One member of the sampling team punched the holes while the other planted the samplers. A photoionization detector (PID) and a three-way gas meter were used to monitor the air at each hole. A tag with the sample number was placed on each sampler, and a wire was attached to each sampler to aid in sampler retrieval. After placing the sampler in the hole, the hole was sealed at the land surface using aluminum foil covered with hydrated bentonite clay.

The samplers were left in place for approximately two weeks. The samplers were retrieved, placed in coolers, and transferred to TEG's laboratory where the sample vapors were desorbed

and analyzed. The samples were analyzed for select chlorinated and non-chlorinated aromatic compounds using modified EPA Methods 8010 and 8020.

4.2.4 Wipe Samples

Wipe samples were collected from the concrete floors of the three ammunition storage magazines to determine whether metals or explosives were present. The samples for metals analysis were collected by swabbing a 10 by 10 centimeter (cm) area with a piece of filter paper moistened with a dilute nitric acid solution supplied by the laboratory. The samples for explosives analyses were collected by swabbing a separate 10 by 10 cm area with an acetone-moistened filter supplied by the laboratory. Each analytical method used required a separate filter. Therefore, five jars were required for each sample: two for the metals analyses (EPA Methods 6010 and 7471) and three for the explosives analyses (EPA Methods 8330, 8321, and 8321 modified).

Disposable templates were used to delineate the sample areas. The samples were collected near the center of the floor of each storage magazine. Each filter was used to wipe a separate 10 by 10 cm area and was placed into a separate sample container. After sampling, a paint marker was used to mark each sample location. One replicate sample was collected by sampling immediately adjacent to the previously sampled area within one of the magazines.

4.2.5 Surface Soil Sampling

Surface soil samples were collected to evaluate the potential presence of soil contamination at the Former Burn Area, Former Buildings 1962 and 1983, Wash Rack No.1, Pesticide Mixing/Storage Building, ASTs, Ammunition Storage Magazines, and Hazardous Material Accumulation Point. For this investigation, surface samples are defined as those collected from 0 to 6 inches deep. Vegetative matter, surface gravel, root mats, and other overlying materials were removed before sampling. Surface soil samples were collected using disposable sampling equipment, including stainless steel spoons and aluminum pans. In some cases, a stainless steel trowel or hand auger was used to penetrate compacted soil. When used, such equipment was decontaminated before use and after collection of each sample, according to the procedures described in the Management Plan. Samples for volatile analyses were collected first and placed directly into laboratory-supplied containers. Samples for non-volatile analyses were homogenized before being placed into the sample containers.

Surface soil samples typically were field screened using a PID. Observations of staining or odors were recorded on the sampling logs, and the soil type was identified. Laboratory analyses of the samples were site specific and are discussed in Section 6. A summary of the surface soil samples collected, including quality assurance/quality control (QA/QC) samples, is provided in Table 4-3. Copies of the surface soil sampling logs are included in Appendix C.

4.2.6 Drilling and Subsurface Soil Sampling

Soil borings were drilled to characterize the subsurface geologic conditions, to obtain soil samples for chemical analysis, and in some locations to install monitoring wells. Soil borings were drilled at all of the sites except Landfill 1, the Former Burn Area, Former Buildings 1962 and 1983, the ASTs, and the Hazardous Materials Accumulation Point. Most of the soil borings were drilled using a hollow-stem auger drilling rig. However, borings at several sites were advanced and sampled using a hand auger or a small-diameter (3-inch) auger/Geoprobe™ system because of site access constraints, UXO concerns, or the shallow sampling depths required. In addition, soil borings at sites requiring UXO support were advanced by hand by the UXO specialists until reaching either natural ground or the estimated potential depth of UXO penetration, as discussed in Section 4.2.1. Following hand augering to the selected depth, the drilling rig was either positioned over the hole or immediately adjacent to it to continue drilling to the desired depth. All soil borings used for the installation of monitoring wells were drilled using a hollow-stem auger drilling rig.

Several soil borings were re-drilled and sampled because of problems with sample shipping. Several coolers of samples shipped on July 24, 1998, were not delivered by the shipping company as directed; therefore, the samples were re-collected from adjacent borings. Borings affected by this included Maintenance Pit boring MP-SB03, Grease Pit borings GP-SB02 and GP-SB03, and Ammunition Storage Magazine boring AS-SB01.

In soil borings advanced using a drilling rig, soil samples were typically collected for PID screening and visual soil classification at 2.5-foot intervals to 20 feet, and at 5-foot intervals thereafter. In hand-augered borings, the soil was observed and described continuously from the auger flights. In Geoprobe™ borings, the soil was observed and screened using samples collected at 2- to 3.5-foot intervals. Subsurface soil samples were collected for chemical analysis from soil intervals exhibiting evidence of contamination (elevated PID readings, odor, and/or visual indications). In addition, soil samples were collected for chemical analyses at the water table (or within the zone of water-table fluctuation), if encountered. Where no evidence of soil contamination was detected, samples were collected from different soil types, if observed, or from designated depths of interest. Sample locations, depths, and analyses are discussed further in Section 6. Soil samples for chemical analysis were collected and handled as described in the Management Plans, except that many of the shallow samples were collected using a hand auger or a Geoprobe™ sampler instead of a split-spoon sampler. Samples for volatile constituent analyses were collected first and were placed directly into the laboratory-supplied containers. Samples for non-volatile constituent analysis were homogenized before being placed into the sample containers.

Laboratory analyses of the samples were site specific and are discussed in Section 6. A summary of the soil boring samples collected, including QA/QC samples, is provided in Table 4-3. Soil boring coordinates, depths, and elevations are summarized in Table 4-4. Logs of borings are presented in Appendix D.

4.2.7 Monitoring Well Installation and Development

Monitoring wells were installed to sample the uppermost groundwater at four of the 17 sites included in this investigation: Landfill 2, Landfill 3, the Pesticide Mixing/Storage Building, and the Former Sewage Pond. Two wells each were installed at the Pesticide Mixing/Storage Building and Former Sewage Pond sites. At each site one well was installed in a location assumed to be upgradient of the suspected contaminant source to evaluate the possible contaminant contribution from off-site sources. The other well or wells were installed in assumed downgradient locations in an attempt to detect contaminants migrating from the suspected site source. Three wells were installed in the Landfill 2 area, and five wells were installed in the Landfill 3 area. One of the wells in each landfill area was installed in an assumed upgradient location; the others were installed in assumed downgradient locations. Because no site-specific hydrogeologic information was available prior to the investigation, the direction of shallow groundwater flow was inferred at each site based on site topography and surface drainage.

4.2.7.1 Well Construction. The monitoring wells were drilled into the uppermost water-bearing layer (sand or gravel) or to the top of bedrock. The wells were constructed using 2-inch inside diameter (I.D.), polyvinyl chloride (PVC) riser pipe and 0.008-inch slotted well screens, with aboveground locking monuments. The wells were typically screened across the water table to allow for monitoring of the uppermost saturated zone and to detect any floating nonaqueous phase liquids (NAPLs). However, at one location (L2-SB01/L2-MW01), the water table was present at such a shallow depth (within 2.6 feet of the land surface during drilling) that the top of the well screen was placed below the water table to allow for proper construction of the well. Because the water table was generally encountered only a few feet beneath the ground surface at the time of drilling, it is anticipated that the top of the screens of most of the monitoring wells will be beneath the water table during part of the year.

At each well, the annulus between the borehole wall and the well screen was backfilled with clean silica filter sand (gradation of 20 to 40 mesh) to above the top of the screen. A bentonite chip seal was then placed above the filter sand, and a surface seal of concrete was placed from the top of the bentonite seal to the ground surface. Because of the shallow water table depth encountered at most of the sites, the thicknesses of the filter pack, bentonite seal, and concrete plug generally had to be reduced from those originally proposed. Bentonite chips placed above the water table were hydrated with potable water. Each well was completed with an aboveground steel monument equipped with a locking cover and padlock.

Following completion of the new well installations, the well locations and the elevations of the concrete pad, steel monument rim, and top of PVC casing were surveyed. Well coordinates, depths, and elevation details are summarized in Table 4-4 and on the boring logs in Appendix D.

4.2.7.2 Well Development. Each well was developed to remove sediment from the well and the formation immediately adjacent to the screen. The depth to water and the well depth were

measured. A bailer was lowered into each well before the start of development, and a water sample was collected from the top of the water column to determine if free product was present.

The wells were developed by bailing and surging using either a disposable bailer or a decontaminated Teflon™ bailer. A graduated bucket was used to estimate the amount of water removed from each well. The elapsed time was noted as the container was filled so that the overall discharge rate could be estimated. Each well was developed until the groundwater temperature, specific conductance, pH, and turbidity had stabilized over three consecutive readings, or for a maximum of about four hours. Field measurements were made periodically during the development of each well. The sampling personnel recorded all field measurements on field forms; copies are provided in Appendix C.

4.2.8 Groundwater Sampling

The static groundwater level was measured in each well using an electronic water level indicator. A complete round of water levels was obtained from all of the new wells at the facility on August 3, 1998. A second round of water level measurements was made on December 16, 1998. Water level measurements were also obtained before collection of groundwater samples from each of the new wells.

Groundwater samples were collected from each of the new monitoring wells to determine if contaminant migration via groundwater is occurring from any of the sites, and to provide a preliminary evaluation of the magnitude of any groundwater contamination identified. Each well was purged and sampled in general accordance with the procedures described in the Management Plan. Most of the groundwater samples were collected using a variable-flow, submersible pump (Grundfos Redi-Flo2) set to a low flow rate to minimize turbulence and therefore turbidity in the samples. The two wells at the Pesticide Mixing/Storage Building were purged and sampled using disposable bailers because of the slow recovery rates in those wells.

Following measurement of the static water level, a bailer was lowered into the well (being careful not to stir up sediment in the well) to check for the possible presence of floating product. Each monitoring well was purged immediately before sample collection so that the sample represented fresh formation water rather than stagnant water that had accumulated in the well casing. Well purging equipment was positioned so that any potential volatile organic sources, such as vehicles, gasoline-driven generators, and fuel tanks, were downwind of the well. This reduced the potential for contamination caused by entrainment of volatile contaminants in the sample.

A graduated bucket was used to estimate the amount of water removed from the well. The elapsed time was noted as the container was filled so that the overall discharge rate could be estimated. The specific conductance, pH, temperature, dissolved oxygen, salinity, and turbidity were measured in the field during well purging and at the time of sample collection. A flow-through cell was used during measurement of these parameters when the pump was used to purge the well. The meters were calibration checked or calibrated at the start of each field day

following the manufacturer's instructions. The wells were purged until the field parameters stabilized, as described in the Management Plan.

Sampling for chemical analyses began by collecting samples for the most volatile parameters first, and proceeding in order of decreasing volatility. Groundwater samples for dissolved metals analyses were field filtered. For pumped wells, the filtering was accomplished by using an in-line system comprised of a 0.45-micron disposable filter connected to the pump discharge tube. Filtering of bailer-collected samples was accomplished at the Pesticide Mixing/Storage Building wells by using a peristaltic pump equipped with disposable Tygon^{TM} tubing and an in-line filter.

Groundwater sample analyses were site specific and are discussed in Section 6. A summary of the groundwater samples collected, including QA/QC samples, is provided in Table 4-5.

4.2.9 Quality Assurance/Quality Control Samples

Duplicate samples were collected at a frequency of 1 per 10 environmental samples. Split samples and matrix spike/matrix spike duplicate (MS/MSD) samples were collected at a frequency of 1 per 20 environmental samples. One trip blank was submitted with each cooler containing water samples for VOC analyses. One rinsate sample was collected during sampling of the groundwater monitoring wells. A sample from the potable water tap used to supply water for drilling, well construction, and decontamination was collected at the end of the field effort.

4.2.10 Investigation-Derived Waste

Investigation-derived wastes (IDW) are wastes generated during sampling activities. IDW generated during this investigation included drill cuttings, decontamination fluids, monitoring well development and purge water, personal protection equipment (PPE), and disposable sampling equipment.

In general, drill cuttings, decontamination fluids, and development and purge water were contained in 55-gallon drums pending results of analytical data for associated environmental samples. In the case of upgradient wells and soil samples, the cuttings, decontamination fluids, and water were returned to the ground surface in the vicinity of intrusive activities. No visible evidence of contamination was observed in these areas during sampling. These procedures were followed to minimize the potential for surface contamination while also minimizing the volume of IDW.

Miscellaneous IDW consisted of used PPE, disposable sampling equipment (spoons, scoops, bailers, etc.), and other wastes that originated from site activities. These IDW were stored in doubled, heavy-duty plastic bags. No grossly contaminated waste PPE was generated during the investigation. The waste PPE and disposable sampling equipment were disposed of in the on-site dumpster.

IDW requiring containerization was placed in clean Department of Transportation (DOT)-approved, 55-gallon drums. The drums were sealed and labeled using a permanent marker with the date, site location, and contents ("soil cuttings," "development/purge water," etc.). These drums were stored on site for appropriate disposition following receipt of chemical analyses of associated soil or water.

None of the IDW was determined to be hazardous, based on the results of associated soil and water sample analyses. Some of the samples exhibited the presence of constituents at concentrations above the screening levels and background concentrations; IDW associated with those samples was disposed of off site.

Drill cuttings from borings exhibiting no elevated concentrations of constituents were spread on the ground adjacent to their source areas (within approximately 5 to 10 feet of the boring location). Drill cuttings from borings with one or more constituents exceeding the screening criteria (and background) were disposed of off site as solid waste.

Monitoring well development and purge water from wells with no constituents detected at concentrations above screening levels was discharged to the ground surface adjacent to the well it came from (within approximately 5 to 10 feet of the well). Development and purge water from wells with one or more constituents exceeding the screening levels was disposed of off site by discharging to an industrial wastewater treatment facility. Decontamination water was handled in the same way as the development and purge water.

4.3 ANALYTICAL METHODS

Analytical data obtained from the field investigations and laboratory testing may be used for a variety of purposes: (1) screening the sites for potential contamination; (2) determining what, if any, additional investigation may be needed; (3) supporting a no further action (NFA) decision, or evaluating or designing a remedial action; and/or (4) supporting possible future human health or ecological risk assessments. In order to meet these data needs in a cost-effective manner, both screening data and definitive data were obtained.

Field screening included use of a PID to check for the presence of VOCs. This technique is qualitative and not compound specific, but provides a rapid indication of the presence of potential contamination. PID screening measurements were obtained during drilling to aid in evaluating the extent of potential contamination and in selecting soil samples to be submitted for laboratory analysis. Field measurements also were obtained for pH, specific conductance, temperature, dissolved oxygen, and turbidity in groundwater samples. Definitive data were obtained by off-site laboratories using standard, documented procedures to provide defensible data on contaminant characterization and contamination levels relative to appropriate regulatory and risk-based criteria.

Each project (Multi-Sites I, II, and III) has its own QAPP. These QAPPs specify the analytical methods and procedures proposed for use in this investigation. Because of analytical method revisions and project laboratory changes during the course of the project, revisions to the Camp Bonneville Multi-Sites II QAPP were submitted in June 1998 (along with the Multi-Sites III Management Plan). Following the Corps' review and approval, this revised QAPP was used to supercede both the Multi-Sites I and II QAPPs. Further details on the modifications to the QAPPs are provided in Appendix F.

The specific analytical methodologies for the definitive analyses, along with the associated project-specified reporting limits (PSRLs), are presented in a series of tables in the QAPP. The PSRLs are based on minimum detection levels that can be expected to be achieved reliably by the project analytical laboratories using the methodologies specified. These tables also present a comparison of the PSRLs with project screening levels, as described in Section 5.

As discussed in the QAPP, some of the analytical methodologies cannot achieve risk-based or cleanup goals for all analytes. Therefore, the analytical methodologies were selected to attain detection or quantitation limits that approach or achieve the risk-based goals for chemicals most likely to be present, with a secondary emphasis on approaching or achieving these goals for the maximum number of other possible contaminants. Analytical results falling between the method detection limit and the project-specified reporting limit have been reported and flagged as estimated values (J-flagged).

Table 4-6 summarizes the methods used during this investigation. Soil samples designated for total petroleum hydrocarbons (TPH) analysis were analyzed initially using the Washington identification method (WTPH-HCID) to determine the petroleum hydrocarbon range of concern. After the WTPH-HCID results were obtained, that information was used to determine if additional analysis was required for gasoline-range petroleum hydrocarbons by Method WTPH-G, diesel-range petroleum hydrocarbons by Method WTPH-D, and/or oil-range petroleum hydrocarbons by Method WTPH-D extended (WTPH-Dx). If the WTPH-HCID results exceeded the reporting limit for gasoline, diesel, or heavy oils, then the specific method was run to quantify the contamination.

4.4 DATA MANAGEMENT AND REVIEW

The data quality was evaluated before use, according to the procedures described in Appendix G. The field and analytical data have been entered in the Air Force Installation Restoration Program Information Management System (IRPIMS) data management format. A copy of the IRPIMS data has been submitted to the Corps in electronic format.

The analytical results for detected compounds are compared with regulatory and risk-based criteria (and background levels, where applicable) in summary tables included in Section 6. The screening criteria used are discussed in Section 5. Appendix H includes complete tables of

results, including both detected and non-detected compounds, along with associated reporting limits and method detection limits.

TABLE 4-1
INVESTIGATION SUMMARY

Site Name	UXO Surveys	Geophysical Surveys	Soil Gas Surveys	Surface Soil Samples	Soil Borings/ Samples	Wipe Samples	Wells/ Water Samples
Landfill 1	1	1					
Landfill 2	1	1	1		3		3
Landfill 3	1	1	1		3		3
Former Burn Area	1			1			
Former Buildings 1962 and 1983				2			
Drum Disposal Area	1	1			3		
Paint and Solvent Disposal Area	1	1			3		
Maintenance Pit					3		
Wash Rack No. 1				2	3		
Grease Pits					3		
Pesticide Mixing/Storage Building				3	3		3
Aboveground Storage Tanks				2			
Former Sewage Pond	3	3			3		3
Ammunition Storage Magazines				2	3	2	
Hazardous Material Accumulation Pt.				2			
Former CS Training Building	3				3		
Wash Rack No. 2					3		
Background Samples				1			
Landfill 4	4	4		4	4		4

Notes:
1 = Phase 1 investigation work
2 = Phase 2 investigation work
3 = Phase 3 investigation work
4 = Phase 4 investigation work (to be presented in a separate report)
UXO = unexploded ordnance

TABLE 4-2
SAMPLE NUMBERING SYSTEM

AA-BB##-$$

AA = Site location, where:

Location ID	Site Name
L1	Landfill 1
L2	Landfill 2
L3	Landfill 3
L4	Landfill 4
BA	Former Burn Area
BD	Former Buildings 1962 and 1983
DB	Drum Disposal Area
PD	Paint and Solvent Disposal Area
BK	Background Locations
MP	Maintenance Pit
WR	Wash Rack No. 1
GP	Grease Pits
PM	Pesticide Mixing/Storage Area
ST	Aboveground Storage Tanks
AS	Ammunition Storage Magazines
HM	Hazardous Material Accumulation Point
CS	Former CS Training Building
W2	Wash Rack No. 2

BB = Type of sample, where:

Type Code	Sample Type
SB	Soil Boring
SS	Surface/Near-surface Soil
SG	Soil Gas
MW	Monitoring Well
MG	Magazine Interior (Soil)
SU	Sump Sample
WP	Wipe Sample

Notes:
= Two-digit sample location number
$$ = Two-digit sequential number

TABLE 4-3
SOIL SAMPLE ANALYSES AND QUANTITIES

Sampling Location/Activity	Number of Environmental Supplies													Number of QA/QC Samples	
	VOCs	SVOCs	PCB/Pest.	Organophos. Pesticides	Chlorinated Herbicides	Lead	PPL Metals	CS	Cyanide	TPH	Explosives*	Total Organic Carbon	Asbestos	Replicate/Split (Q/CMQAL)	MS/ MSD
Landfill 2/Landfill 3															
Soil Borings	8	8	8				8		8	8	8	8		1/1	1
Burn Area															
Surface Soil Samples	10	10	10				10			10	10			1/1	1
Former Buildings 1962 and 1983															
Surface Soil Samples		15				15							15	1/1	1
Drum Disposal Area															
Soil Borings	2	2	2				2			2	2				
Paint/Solvent Disposal Area															
Soil Borings	4	4	4				4			4	4			1/0	
Maintenance Pit															
Soil Borings	5	6	6				6			6					
Wash Rack No. 1															
Surface Soil Samples		2	2				2			2					
Soil Borings	2	3					3			3					
Grease Pits															
Soil Borings	4	4	4				4			4				1/0	
Pesticide Mixing/Storage Building															
Surface Soil Samples		2	2	2	2		2			2					
Soil Borings	7	9	9	9	9		9			9				1/1	1
Aboveground Storage Tanks															
Surface Soil Samples										8				1/0	
Former Sewage Pond															
Soil Borings	13	15	15				15			15				2/1	1
Ammunition Storage Magazines															
Surface Soil Samples							17				17			2/1	1
Soil Borings							2				2				
Wipe Samples							3				3			1/0	
Hazardous Material Accumulation Point															
Surface Soil Samples		2	2				2			2				1/1	1
Former CS Training Building															
Surface Soil Samples		4				4		5	5						
Subsurface Soil Samples		1				1		5	5					1/1	1
Wash Rack No. 2															
Surface Soil Samples		2					2			2				1/0	
Subsurface Soil Samples		2					2			2					
Background Locations															
Surface Soil Samples							20							2/2	1
TOTALS	55	91	64	11	11	20	95	10	18	79	46	8	15	17/10	9

Notes:

CMQAL = Chemical and Materials Quality Assurance Laboratory
MS/MSD = matrix spike/matrix spike duplicate
PCB = polychlorinated biphenyl
PPL = priority pollutant list
Q = Quanterra Environmental, Inc.
QA = quality assurance
QC = quality control
SVOC = semivolatile organic compound
TPH = total petroleum hydrocarbons
VOC = volatile orgainic compound
* Includes nitroaromatics and nitramines by EPA Method SW8330, PETN by EPA Method SW8321, and Picric Acid by EPA Method SW8321 modified.

TABLE 4-4
DETAILS OF SUBSURFACE EXPLORATIONS

Boring Number	Well Number	Ecology Well Designation	Date Installed	Coordinates		Concrete Pad Elevation (feet)	Ground Elevation (feet)	PVC Casing Rim Elevation (feet)	Monument Rim Elevation (feet)	Boring Depth (feet bgs)	Well Depth (feet btoc)	Well PVC Stickup (feet)	Well Depth (feet bgs)	Screened Interval (feet bgs)	8/3/1998 Water Elevation (feet)
				Northing (feet)	Easting (feet)										
	Existing Well			138428.173	1152790.141	N.A.	Approx. 339.7	340.248	N.A.	10.5?	10.95	Approx. 0.5	10.5	0-10	334.12*
L2-SB01	L2-MW01	AEA936	7/14/1998	138249.743	1152566.01	336.304	Approx. 336.2	339.18	339.13	30.1	16.3	3	13.3	3.1-12.8	333.46
L2-SB02	L2-MW02	AEA935	7/15/1998	138127.105	1152449.835	335.87	Approx. 335.8	338.56	338.40	15.1	15.5	2.8	12.7	2.4-12.2	332.75
L2-SB03	L2-MW03	AEA930	7/17/1998	138734.662	1152277.738	364.253	Approx. 364.2	367.26	367.25	10.5	13.5	3.1	10.4	3-10.2	Dry (<354.0)
L3-SB01			7/14/1998	138254.895	1152860.959		338.102			25.2					
L3-SB02	L3-MW01	AEA933	7/15/1998	138203.545	1152821.264	337.182	Approx. 337.0	340.32	340.17	15.1	15.3	3.3	12	1.7-11.5	333.20
L3-SB03	L3-MW02	AEA932	7/15/1998	138307.878	1152821.367	337.788	Approx. 337.8	340.89	340.80	14.3	16.6	3.1	13.5	3.2-13	333.41
L3-SB04	L3-MW03	AEA934	7/16/1998	138193.191	1152730.34	337.574	Approx. 337.6	340.58	340.41	16	16.5	3	13.5	3.2-13	333.50
L3-SB05	L3-MW04	AEA931	7/16/1998	138373.532	1152545.928	338.503	Approx. 338.1	341.16	341.17	30.7	16	3.1	12.9	2.6-12.4	335.43
DB-SB01			7/22/1998	135739.17	1148664.802		323.03			5					
DB-SB02			7/22/1998	135728.149	1148668.559		322.557			5					
PD-SB01			7/22/1998	135914.895	1148165.506		346.898			4					
PD-SB02			7/22/1998	135897.722	1148171.843		345.75			4					
PD-SB03			7/22/1998	135945.783	1148078.785		349.042			3					
PD-SB04			7/22/1998	135939.548	1148078.736		348.29			2.5					
MP-SB01			7/22/1998	136142.572	1147897.039		366.993			11.5					
MP-SB02			7/23/1998	136127.5	1147906.5		Approx. 366			3.8					
MP-SB03			7/24/1998	136117.349	1147914.439		365.474			5.5					
MP-SB03A			8/5/1998	136114.453	1147908.407		364.999			5.5					
WR-SB01			7/22/1998	136111.92	1147865.379		364.484			11.5					
GP-SB01			7/23/1998	138015.574	1150839.929		374.411			12.5					
GP-SB02			7/23/1998	138021	1150846		373.8			9.5					
GP-SB02A			8/4/1998	138020.663	1150846.351		373.797			8					
GP-SB03			7/24/1998	136223	1147671		376.5			6.5					
GP-SB03A			8/3/1998	136223.235	1147671.279		376.543			7					
PM-SB01			7/21/1998	137777.362	1150520.433		363.767			40					
PM-SB01A	PM-MW01	AEA927	7/22/1998	137784.089	1150518.132	364.485	Approx. 364.5	367.67	367.48	29	30.4	3.2	27.2	3.4-27	347.95
PM-SB02	PM-MW02	AEA928	7/22/1998	137693.598	1150582.852	353.277	Approx. 353.4	356.36	356.17	21.5	23.1	3	20.1	4.2-19.9	344.10
PM-SB03			7/22/1998	137734.705	1150559.657		358.302			6.5					
SP-SB01			7/17/1998	137304.486	1151047.491		331.962			21.5					
SP-SB02			7/17/1998	137316.4	1151009		332.6			6					
SP-SB02A			7/20/1998	137317.367	1151008.926		332.602			20.5					
SP-SB03			7/20/1998	137331.778	1151038.499		332.818			20.5					
SP-SB03A			7/20/1998	137332	1151038		332.8			4.5					
SP-SB04	SP-MW01	AEA926	7/20/1998	137251.615	1151046.022	329.536	Approx. 329.9	332.99	332.84	15	16	3.1	12.9	2.6-12.4	326.38
SP-SB05	SP-MW02	AEA929	7/21/1998	137464.45	1150966.959	334.375	Approx. 334.2	337.16	337.09	19	19.9	3	16.9	3.1-16.7	329.35
AS-SB01			7/23/1998	138121	1151850		345.2			11.5					
AS-SB01A			8/4/1998	138121.426	1151850.432		345.238			8					

Notes: * = Measured on 8/6/98.
bgs = below ground surface.
btoc = below top of PVC casing.
N.A. = not applicable.
PVC = polyvinyl chloride.
Horizontal coordinates are based on the Washington State Coordinate System, South Zone, NAD 83/91.
Vertical control is based on NGVD 29.

TABLE 4-5
WATER SAMPLE ANALYSES AND QUANTITIES

Sampling Location	Number of Environmental Supplies												Number of QA/QC Samples			
	TPH	PPL Metals Total[a]	PPL Metals Dissolved[a]	VOCs	SVOCs	PCBs/ Pesticides	Organo-phosphorus Pesticides	Chlorinated Herbicides	Explosives[b]	Cyanide	Conventional Analyses[c]	Fecal Coliform, Fecal Strep	Replicate/ Split (Q/CMQAL)	Rinsate Blank	Trip Blank (Q/CMQAL)	MS/MSD
Landfill 2/Landfill 3																
Monitoring Wells	7	7	7	7	7	7			7	7			1/1	1	4/1	1
Former Sewage Pond																
Monitoring Wells	2	2	2	2	2						2	2			1	
Pesticide Mixing/Storage Building																
Monitoring Wells	2	2	2	2	2	2	2	2			2					
Hazardous Materials Accumulation Point																
Sump	1	1		1	1	1										
Drilling Water																
Tap Water	2	2		2	2	2	2	2	2	2	2	2				
TOTALS	14	14	11	14	14	12	4	4	9	9	6	4	1/1	1	5/1	1

Notes:

[a] Includes barium

[b] Includes nitroaromatics and nitramines by EPA Method SW8330, PETN by EPA Method SW8321, and Picric Acid by EPA Method SW8321 modified.

[c] Includes common cations, common anions, carbonate/bicarbonate, and total suspended solids.

CMQAL = Chemical and Materials Quality Assurance Laboratory
MS/MSD = matrix spike/matrix spike duplicate
PCB = polychlorinated biphenyl
PPL = priority pollutant list
Q = Quanterra Environmental, Inc.
QA = quality assurance
QC = quality control
SVOC = semivolatile organic compound
VOC = volatile organic compound
TPH = total petroleum hydrocarbons

TABLE 4-6
ANALYTICAL PROCEDURES

Procedure	Method
Total Petroleum Hydrocarbons – Gas Chromatograph	WTPH-HCID, WTPH-G, WTPH-D, WTPH-D Extended
Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs)	SW846-8081
Volatile Organic Compounds (VOCs) – Gas Chromatograph/Mass Spectrophotometer (GC/MS)	SW846-8260A
Semivolatile Organic Compounds (SVOCs) – GC/MS	SW846-8270B
Organophosphorus Compounds	SW846-8141A
Chlorinated Herbicides	SW846-8150B
Nitroaromatics and Nitramines - High Performance Liquid Chromatography (HPLC)	SW846-8330
Ammonium Picrate/Picric Acid (AP/PA)	SW846-8321 modified
Pentaerythritol Tetranitrate (PETN)	SW846-8321
CS and Breakdown Products – GC/MS	SW846-8270C modified
Metals – Inductively Coupled Plasma/Mass Spectrometry (ICP/MS)	SW846-6020
Mercury – Cold Vapor Extraction (CVE)	SW846-7470A/7471A
Cyanide (CN)	SW846-9012
Common Anions (Chloride, Sulfate, Fluoride, Nitrate, Orthophosphate)	SW846-300.0
Common Cations (Calcium, Iron, Magnesium, Potassium, Sodium)	SW846-6010A
Carbonate/Bicarbonate (Alkalinity)	E310.1
Total Suspended Solids	E160.2
Asbestos	EPA-600
Moisture	ASTM D 2216
Total Organic Carbon (TOC)	Walkley-Black
Fecal Coliform	SM Part 900
Fecal Streptococcus	SM Part 900

Notes:
ASTM = American Society for Testing and Materials
E = Methods for Chemical Analysis of Water and Wastewater (EPA, 1983)
EPA = U.S. Environmental Protection Agency
SM = Standard methods for the examination of water and wastewater (APHA, 1989 and 1992)
SW846 = Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (EPA, 1986, 1992, 1994, and 1996)
WTPH = Washington Total Petroleum Hydrocarbons method (Ecology, 1992)

5.0 COMPARISON CRITERIA

Comparison criteria, or screening levels, for the project consist of regulatory and risk-based limits for soil and groundwater, as well as background levels established for metals in soils. In Section 6, the sample results are compared with these criteria to determine which constituents present a concern at each site. However, these criteria should not be construed as site-specific cleanup standards.

5.1 CLEANUP LEVELS AND RISK-BASED CONCENTRATIONS

Maximum Contaminant Levels. Maximum contaminant levels (MCLs) and non-zero MCL goals for groundwater were obtained from the EPA Drinking Water Regulations and Health Advisories, February 1996, EPA 822-R-96-001. In addition, the EPA-recognized action level of 15 micrograms per liter (µg/L) for lead in groundwater has been used (40 Code of Federal Regulations [CFR] 141.80).

EPA Region 3 Tap Water. Risk-based concentrations for tap water were obtained from EPA Region 3 (and adopted by EPA Region 10). These concentrations are based on a default residential groundwater use scenario and a 10^{-6} cancer risk or a hazard quotient of 1 (EPA Region 3, 1996).

EPA Region 3 Risk-Based Concentrations for Residential Exposure to Soil. Residential soil ingestion risk-based concentrations (RBCs) were obtained from the table prepared by EPA Region 3 (and adopted by EPA Region 10) (EPA Region 3, 1996).

MTCA Method A. MTCA Method A cleanup level values for soil and groundwater were obtained from the MTCA Cleanup Regulation, Chapter 173-340 of the Washington Administrative Code (WAC) (Ecology, 1996a). These cleanup levels are not site specific and are applicable to sites undergoing routine cleanup actions as defined in MTCA. Establishment of actual MTCA Method A cleanup levels requires meeting requirements for use of Method A and consideration of applicable laws, achievable quantitation limits, background concentrations, and other factors in addition to the values listed in the Method A tables.

MTCA Method B. MTCA Method B risk-based concentrations for soil/sediment and groundwater were obtained from the MTCA Cleanup Levels and Risk Calculations (CLARC) II database (based on a 10^{-6} cancer risk or a hazard quotient of 1) (Ecology 1996a; and Ecology 1996b). These are formula values obtained from the February 1996 CLARC II Update (Ecology, 1996b). Establishment of actual MTCA Method B cleanup levels requires considering applicable laws, site-specific information, cross-media impacts, and other factors in addition to formula risk-based calculations. Method B is the standard method of determining cleanup levels under MTCA and is applicable to all sites. Method B RBCs were not derived for chemicals that are not listed in the CLARC II database.

MTCA Method B for Groundwater Protection. Soil concentrations (in milligrams per kilogram [mg/kg]) for the protection of groundwater are based on MCLs or the MTCA Method B groundwater concentration (in milligrams per liter [mg/L]) times the MTCA attenuation factor of 100 (Ecology 1996a; and Ecology 1996b).

5.2 BACKGROUND CONCENTRATIONS FOR SOILS

Data for natural background concentrations of metals in soil were obtained from two sources. Ecology (1994) has reported on background metals concentrations for soil within the state of Washington and for several regions within the state. Not all of the metals analyzed during this study are included in the Ecology report. In addition, copper was typically detected at the investigation sites at concentrations exceeding the Ecology background concentrations. Background soil samples were collected at Camp Bonneville and were statistically evaluated to establish concentrations representative of area background.

5.2.1 Statewide Background

Ecology conducted a study to measure the natural background concentrations of metals in soil throughout Washington State. The report, titled *Natural Background Soil Metals Concentrations in Washington State,* provides background data for selected regions, as well as statewide (Ecology, 1994). One of the regions investigated was the Clark County area. Soil samples used in the study were collected from the ground surface to a depth of 3 feet.

Natural background soil metals concentrations can be used to establish a cleanup standard for a hazardous substance for which no applicable or relevant and appropriate requirement (ARAR) exists (Chapter 173-340-700 [4][d] WAC). Natural background concentrations can also be used to replace existing Method A or Method B cleanup standards that are below the natural background level (Chapter 173-340-700 [1][a] WAC). Numbers typically used for comparison are the 90^{th} percentile values for the data. Statewide and Clark County 90^{th} percentile natural background values are shown in Table 5-1. According to the Ecology report, use of the statewide 90^{th} percentile values is unrestricted (i.e., they can be compared with data from anywhere within the state). The regional (for example, Clark County) 90^{th} percentile numbers are to be compared only with data from that region.

The Ecology 90^{th} percentile numbers ideally are compared with the 95 percent upper confidence limit (UCL) of a given data set when comparing site data with background values. However, because of the limited number of data points collected from most of the investigation sites, such a statistical comparison is not practical. When comparing individual data points with the 90^{th} percentile values, there is a 10 percent chance that an individual data point from an unaffected site will exceed the 90^{th} percentile value. According to Ecology, if background values are used as cleanup levels, no single sample concentration shall be greater than two times the 90^{th} percentile value, and less than 10 percent of the sample concentrations shall exceed the 90^{th} percentile value (WAC Chapter 173-340-7407[e]).

5.2.2 Site Background

Surface and near-surface soil samples were collected at Camp Bonneville to determine background concentrations of metals in soil. Ten background locations (BK-SS01 through BK-SS10) were sampled. Two soil samples were collected from each location: one from 0 to 1 foot bgs and one from 1 to 2 feet bgs. The sample locations were distributed around the facility, generally near the perimeter on the west, northwest, and southwest sides (Figure 5-1). An attempt was made to locate relatively undisturbed areas for sampling. Two locations (BK-SS01 and BK-SS02, Figure 5-1) were selected near Lacamas Creek, close to the point were it exits the site to the west. These locations were selected in an attempt to look at the chemical composition of floodplain soils. Duplicate/split and MS/MSD samples were collected with sample BK-SS04-01. Duplicate/split samples were also collected with sample BK-SS04-02. Table 5-2 provides a summary of the metals concentrations detected.

Most of the samples were collected from densely wooded areas. Sampling typically started several inches bgs, as the root mat was typically quite dense. Sample depths were influenced, in some cases, by the presence of roots, very dense clay, gravel, or cobbles. Samples for duplicates, splits, and MS/MSDs were co-located and homogenized together.

The metals data were analyzed to establish concentrations representative of area background. Background values were calculated only for metals that tended to exceed both the risk-based or regulatory criteria and the Ecology background values in on-site soils. Background values could not be calculated for antimony or thallium because the majority of the concentrations detected were reported as estimated (detected at a concentration between the method detection limit [MDL] and the reporting limit [RL]). The maximum concentrations of these two metals have been listed in Table 5-1 for comparison purposes.

Summary statistics were calculated using concentrations for barium and copper. Before summary statistics were calculated, field duplicates were compared with field samples to determine which samples would be included in the data set, and statistical tests were applied to determine what types of distributions were present. Twenty field samples and two field duplicates were collected. A duplicate was compared with its corresponding field sample, and the lowest concentration was included in the data set. Distributions were tested for normality and lognormality using the Shapiro-Wilk test (SPSS, 1997). No data set fits a normal distribution. One data set, for barium, fit a lognormal distribution. The distribution for copper was assumed to be nonparametric.

The summary statistic calculated for barium was the 90^{th} percentile of the lognormal distribution (Ecology, 1992). This statistic was calculated using the following formula:

$$Y = \exp (X + Z_{90}\ SD)$$

where:

Y	=	90^{th} percentile of the lognormal distribution.
X	=	mean of the $\log_e$-transformed data.
Z_{90}	=	value from the normal distribution corresponding to the 90^{th} percentile.
SD	=	standard deviation of the $\log_e$-transformed data.

The summary statistic used for copper was the 90^{th} percentile calculated using the nonparametric (distribution-free) method (Ecology, 1992). This method ranks the data in ascending order and uses the value with the rank corresponding to the desired percentile and given by the following formula:

$$V = p/100\ (n+1)$$

where:

V	=	rank of the p^{th} percentile data.
p	=	percentile (i.e., 90).
n	=	number of samples (i.e., 20).

In cases where V was not an integer, linear extrapolation between two data points was used.

5.2.3 Background Concentrations Used for Screening Criteria

Many of the statewide natural background numbers are the same as or similar to the Clark County numbers; however, the statewide background numbers for chromium and mercury are more representative of concentrations detected in background soil samples from Camp Bonneville. In an effort to use published numbers to the extent possible, the statewide background numbers were selected for comparison, rather than the Clark County numbers. Camp Bonneville-specific background numbers were calculated only for metals that exceeded the default Ecology background values, or for which no Ecology values were available.

Table 5-1 includes a summary of available background numbers (90^{th} percentile) for metals in soils for statewide, Clark County, and Camp Bonneville-specific samples. The shaded numbers are those selected for use as screening criteria.

TABLE 5-1
90TH PERCENTILE NATURAL BACKGROUND VALUES FOR METALS IN SOILS (in mg/kg)

Metal	Statewide	Clark County	Camp Bonneville
Antimony	NA	NA	0.12 [a]
Arsenic	7	6	NC
Barium	NA	NA	257
Beryllium	2	2	NC
Cadmium	1	1	NC
Chromium	42	27	NC
Copper	36	34	114
Lead	17	17	NC
Nickel	38	21	NC
Selenium	NA	NA	NC[b]
Silver	NA	NA	NC[b]
Thallium	NA	NA	0.27[a]
Zinc	86	96	NC
Mercury	0.07	0.04	NC

Notes:
[a] The value indicated is the maximum value detected.
[b] No value was calculated for this metal because the regulatory screening criteria were well above any concentrations detected in background samples.
mg/kg = milligrams per kilogram
NA = not available
NC = not calculated
Shading indicates that the concentration was selected for use as project background.

TABLE 5-2
BACKGROUND SOIL SAMPLE RESULTS
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration													
		BK-SS01-01	BK-SS01-02	BK-SS02-01	BK-SS02-02	BK-SS03-01	BK-SS03-02	BK-SS04-01	BK-SS04-02	BK-SS05-01	BK-SS05-02	BK-SS06-01	BK-SS06-02	BK-SS07-01	BK-SS07-02
Sample Date		12/10/1997	12/10/1997	12/10/1997	12/10/1997	12/13/1997	12/13/1997	12/17/1997	12/17/1997	12/15/1997	12/15/1997	12/15/1997	12/15/1997	12/17/1997	12/17/1997
Sample Depth (ft bgs)		0.25	1	0.25	1	0.25	1	0.25	1	0.25	1	0.25	1.3	0.25	1
Metals															
Antimony	mg/kg	0.074 J	0.084 J	0.074 J	0.052 J	0.071 J	0.075 J	0.013 J	0.093 J	0.088 J	0.072 J	0.075 J	0.045 J	0.12 J	0.082 J
Arsenic	mg/kg	**1.9**	**2.9**	**1.8**	**1.8**	**2.3**	**2.5**	**2.7**	**2.9**	**1.8**	**1.6**	**2.1**	**1.8**	**2.1**	**2.3**
Barium	mg/kg	**166**	**124**	**172**	**189**	**123**	**114**	**152**	109	**188**	**193**	98	74.8	**353**	**236**
Beryllium	mg/kg	**1.1**	**1.1**	**1.1**	**1.1**	**0.91**	**1.1**	**0.74**	**1.0**	**0.85**	**0.81**	**0.79**	**0.9**	**1.2**	**1.2**
Cadmium	mg/kg	0.072 J	0.038 J	0.085 J	0.082 J	0.072 J	0.057 J	0.030 J	0.010 J	0.093 J	0.083 J	0.053 J	0.021 J	0.11 J	0.042 J
Chromium	mg/kg	**26.9**	**31.0**	**30.7**	**30.8**	**31.8**	**32.0**	**24.0**	**27.5**	**30.8**	**30.2**	**19.2**	**15.8**	**26.4**	**33.2**
Copper	mg/kg	**72.7**	**82.5**	**78.5**	**74.9**	**75.2**	**67.1**	21.3	25.2	**117**	**125**	17.1	19.1	26.3	31.2
Lead	mg/kg	10.6	8.6	10.0	7.7	11.6	10.3	13.7	14.2	11.0	9.1	19.3	12.7	23.0	14.4
Nickel	mg/kg	11.2	10.3	12.2	12.4	15.8	13.7	11.7	13.0	11.9	12.1	8.9	7.1	10.7	13.3
Selenium	mg/kg	ND	ND	0.27 G,J	0.31 G,J	0.31 G,J	0.33 G,J	0.14 J	ND	ND	ND	ND	0.21 G,J	ND	ND
Silver	mg/kg	0.22	0.21	0.23	0.22	0.18	0.22	0.22	0.31	0.22	0.18	ND	.10 J	0.44	0.66 G
Thallium	mg/kg	ND	ND	ND	ND	0.027 J	0.020 J	**0.12 J**	0.010 J	ND	ND	ND	.060 J	**0.19**	**0.19**
Zinc	mg/kg	67.8	52.0	69.3	64.6	66.4	60.1	43.3	37.6	81.4	82.3	36.8	34.4	94.6	74.5
Mercury	mg/kg	0.046 J	0.037 J	0.051 J	0.047 J	0.072 J	0.065 J	0.058 J	0.054 J	0.052 J	0.065 J	0.093 J	0.060 J	0.082 J	0.047 J

TABLE 5-2
BACKGROUND SOIL SAMPLE RESULTS
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Sample Concentration								Regulatory/Risked-Based Criteria			
	BK-SS08-01	BK-SS08-02	BK-SS09-01	BK-SS09-02	BK-SS10-01	BK-SS10-02	BK-SS11-01	BK-SS11-02	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3
							(dup SS04-01)	(dupSS04-02)				
Sample Date	12/18/1997	12/18/1997	12/18/1997	12/18/1997	12/18/1997	12/18/1997	12/17/1997	12/17/1997				
Sample Depth (ft bgs)	0.25	1	0.25	1	0.25	1	0.25	1				
Metals												
Antimony	0.098 J	0.082 J	0.11 J	0.096 J	0.062 J	0.056 J	0.065 J	0.085 J	NA	32 - 72[a]	0.64 - 1.44[a]	31
Arsenic	**2.4**	**2.3**	**2.7**	**3.5**	**1.8**	**1.7**	**2.7**	**2.9**	20	1.67	0.005	0.43
Barium	**261**	**260**	**162**	103	**138**	**151**	**158**	93.4	NA	5,600	112	5,500
Beryllium	**0.78**	**0.91**	**0.83**	**0.89**	**0.90**	**0.90**	**0.78**	**0.93**	NA	0.233	0.002	0.15
Cadmium	0.072 J	0.051 J	0.034 J	0.015 J	0.031 J	ND	0.016 J	ND	2	80	1.6	39
Chromium	**20.8**	**26.2**	**27.2**	**31.8**	**27.4**	**29.0**	**23.8**	**29.4**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]
Copper	**78.7**	**89.4**	30.7	40.6	18.5	24.4	18.2	22.9	NA	2,960	59.2	3,100
Lead	15.0	11.4	15.0	16.6	15.1	12.9	14.2	14.0	250	NA	NA	400[d]
Nickel	11.4	14.5	8.2	11.5	7.0	10.7	10.7	12.0	NA	1,600	32	1,600
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	NA	400	8	390
Silver	0.2	0.27	0.16	0.27	0.4	0.47	0.22	0.33	NA	400	8	390
Thallium	ND	ND	0.051 J	0.071 J	**0.27**	0.031 J	0.012 J	ND	NA	5.6	0.112	6.3 - 7[e]
Zinc	71.6	78.5	47.1	44.1	44.6	43.5	37.0	36.0	NA	24,000	480	23,000
Mercury	0.053 J	0.036 J	0.049 J	0.033 J	0.047 J	0.032 J	0.063 J	0.052 J	1	24	24	7.8[f]/23[g]

Notes:

Shading indicates that the level exceeds one or more regulatory/risk-based criteria.

ft bgs = feet below ground surface (top of sampling interval)

EPA = U.S. Environmental Protection Agency

mg/kg = milligrams per kilogram

MTCA A = Washington State Model Toxics Control Act Method A criteria

MTCA B = Washington State Model Toxics Control Act Method B criteria

MTCA B-GW = Washington State Model Toxics Control Act Method B criteria for the protection of groundwater

ND = not detected above the method detection limit

[a] = Varies with the form of antimony

[b] = Chromium III

[c] = Chromium VI

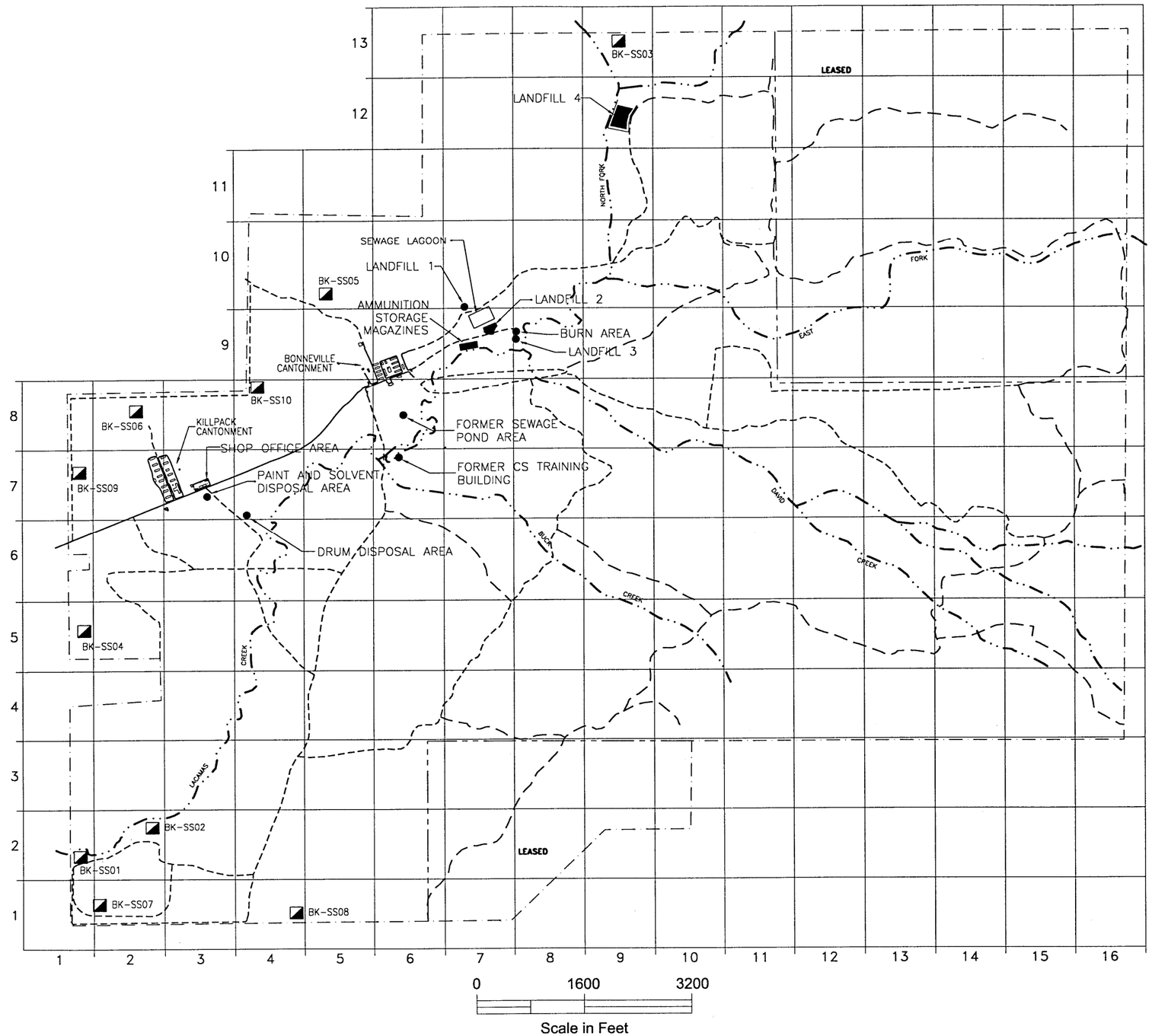
[d] = EPA screening level based on Integrated Exposure Uptake Biokinetic (IEUBk) model

[e] = Varies with the form of thallium

[f] = Methyl mercury

[g] = Inorganic mercury

J = Result was detected below the reporting limit or is an estimated concentration.



N

LEGEND

- INSTALLATION PROPERTY BOUNDARY
- LEASED AREAS BOUNDARY
- ALL WEATHER, HARD SURFACE, ASPHALT ROAD
- ALL WEATHER, LOOSE SURFACE, GRAVEL ROAD
- FAIR WEATHER, LOOSE SURFACE, EARTHEN ROAD
- CREEKS
- BK-SS01 BACKGROUND SOIL SAMPLING LOCATION AND DESIGNATION

Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

BACKGROUND SAMPLE LOCATIONS

July 1999 T-4110-05

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 5-1

6.0 SITE EVALUATIONS AND INVESTIGATION RESULTS

6.1 LANDFILL 1

6.1.1 Site Characteristics

This disposal area reportedly is located east of the Camp Bonneville cantonment area and just north of the existing sewage lagoon (Figure 2-1). It was identified as having potential historic significance, based on a 1980 cultural resources survey (Larson, 1980), which stated that bottle fragments dating from the early 1900s were found in the area. There is no record of when the site was used or what types of material it may contain. In the 1980 survey, the site was described as a small (approximately 12-foot by 15-foot) shallow depression. This site was assigned BRAC parcel number 2(7)HR(P).

6.1.2 Site Investigations and Findings

UXO avoidance/screening surveys were performed using a two-person crew in the general area where the landfill was reportedly located; its exact location was not known. On December 9, 1997, the UXO specialists swept a large area generally north and northwest of the existing sewage lagoon. A Shannon & Wilson representative, a representative of the Corps, and the Camp Bonneville Facility Manager followed behind the UXO specialists, looking for evidence of the landfill area; however, nothing was found.

On December 12, 1997, the UXO specialists and geophysicist, the Corps on-site representative, and the Facility Manager made another search of the area. The group spread out in a line and walked together across the area of the reported landfill. Three different types of meters were used to search for buried landfill debris. The meters included Fisher and Garrett metal locators, both of which are EM devices and create a magnetic field in the detector to locate buried objects made of any type of metal. In addition, a Schonstedt flux-gate gradiometer (the standard UXO detection device) was used. The Schonstedt uses existing magnetic fields to detect buried ferrous metal. The area surveyed was covered with dense vegetation, including trees and thick underbrush. No evidence of the landfill was found using the magnetometers, nor was visual evidence of the landfill found, either in the way of a depression as previously described, or any debris at the ground surface.

As directed by the Corps on-site representative, attempts to locate Landfill 1 were ended after these considerable efforts. Based on this survey work, it is likely that the term "landfill" may not be appropriate for this site. Rather, it may have been an area where some household debris (such as the old bottles fragments) were disposed of from an old homestead that used to be in this area.

6.2 LANDFILL 2

6.2.1 Site Characteristics

This former landfill was discovered about 1978, during excavation for construction of the current sewage lagoon. According to an interview performed during the EBS, landfill material was unearthed at the eastern and northern borders of the sewage lagoon. No description of the materials encountered during construction of the sewage lagoon was found. There is no record of the type or quantity of material that was placed in this landfill, and the dates of use are not known. However, its use apparently preceded the mid-1970s, based on the lack of knowledge about it from base personnel who were working there at that time. The EBS suggests that the landfill was probably operated from 1940 to 1950. This site was assigned BRAC parcel number 3(7)HR(P).

The general landfill area is bounded by the existing sewage lagoon to the west and north, and wooded areas to the south and east (Figure 6-1). The landfill area slopes gently southward toward Lacamas Creek. Although most of the site area is fairly flat, portions of the area are bumpy and uneven. The area between the sewage lagoon and the gravel road to the south is covered with native grasses. Photographs of the site are provided in Appendix A.

6.2.2 Site Investigations

Tasks performed at this site included UXO avoidance surveying, geophysical surveying, soil gas surveying, drilling and subsurface soil sampling, monitoring well installation, and groundwater sampling. The initial site characterization work was performed during the Phase 1 investigation. The drilling, well installation, and sampling tasks were performed during the Phase 3 investigation.

A UXO avoidance/screening survey was performed on December 8 and 9, 1997. Magnetic anomalies were flagged and avoided during subsequent activities at the site. A large area was initially surveyed, and additional areas were surveyed, as needed, as the field work progressed.

An EM survey was performed over the Landfill 2 area on December 11 and 12, 1997. GPR was not used as the primary geophysical method because of the high natural ground conductivity, uneven terrain, and the presence of ponded water; however, two GPR traverses were run across the site. Based on the results obtained in the field, the EM survey was extended into the trees on the east side of the suspected landfill area, and across to the south of the gravel road.

A soil gas survey also was performed during December 1997. Sixty-four soil gas samplers were planted in a grid pattern over the landfill and adjacent areas, as delineated by the geophysical survey. The samplers were installed on December 15 and 16, 1997, and were retrieved on December 29, 1997. Locations of the soil gas samples are provided in Appendix B.

Three soil borings were drilled in the Landfill 2 area during July 1998. Monitoring wells were installed in all three borings. The monitoring wells were installed in locations assumed to be upgradient (one well) and downgradient (two wells) of the landfill, based on area topography and surface drainage. Each soil boring was initially advanced by the UXO specialists to a depth of approximately 5 to 7 feet bgs. The drilling rig was then moved over the hole (or immediately adjacent to it), and drilling continued by the hollow-stem auger method. One soil sample was collected for chemical analysis at or immediately above the water table in each of the downgradient soil borings. (No groundwater was encountered in the upgradient boring.) Because the UXO specialists had to advance the holes to depths below the water table (for safety purposes), soil samples for chemical analysis were collected from the hand auger barrel in the two downgradient borings. A soil sample was collected from the anticipated wet season water table zone at the upgradient boring (L2-SB03) using a split-spoon sampler.

Because suspect landfill material was found to extend to and slightly into a dense stand of trees south of the gravel road, the two downgradient monitoring wells (L2-MW01 and L2-MW02) were installed to the south of the trees, as close to the landfill as possible (Figure 6-1). These two wells were installed to depths of 13.3 feet and 12.7 feet bgs, respectively. The upgradient well (L2-MW03) was installed to a depth of 10.4 feet bgs, near the northeast corner of the sewage lagoon, to allow for potential seasonal monitoring of groundwater. This depth corresponded with the top of the bedrock, which is expected to perch shallow groundwater during the rainy season.

The two downgradient wells were developed on July 28 and 29, 1998. Approximately 44 and 45 gallons of water were removed from L2-MW01 and L2-MW02, respectively, over a period of approximately four hours each. The two wells were sampled on August 4 and August 6, 1998 (Table 6-1). A rinsate blank also was collected using the sampling pump, following sampling of well L2-MW02.

6.2.3 Field Observations

A considerable amount of metallic debris (including pipes, vehicle parts, and wiring) was detected at and near the land surface during the UXO avoidance survey. No UXO-related debris was observed during the field investigation; however, an undetonated 2.76-inch LAW round was located during early scoping surveys of the Landfill 2 site. Fort Lewis Explosive Ordnance Demolition (EOD) personnel were brought to the base for in situ detonation of the shell.

The geophysical survey indicated that the landfill likely extends into the trees to the east and past the gravel road, and into the trees to the south. A report on the geophysical survey findings for Landfill 2 is presented in Appendix B. Three areas of low conductivity values were identified at Landfill 2. The conductivity lows at the junction of the access road and the sewage lagoon entrance road and along the entrance road are suspected to originate from a pipeline that runs to the sewage lagoon. The conductivity low observed to the east of the north-south road to the sewage lagoon is interpreted to reflect buried landfill debris. This conductivity low is centered at an area where metal debris was observed protruding from the ground surface. The third

conductivity low lies south of the north-south road. The conductivity values in this area are typical of landfill debris; that is, the results do not show a trend but rather a random rising and falling along each traverse. These conductivity lows and highs were found in an area of low-relief mounds, south of the edge of the road. The approximate landfill boundary, as determined by the geophysical survey, is shown on Figure 6-1.

6.2.3.1 Soil

The downgradient soil borings generally encountered 3 to 5 feet of brown, silty clay/clayey silt with varying amounts of sand, underlain by 5 to 7 feet of brown, silty, gravelly sand to silty, sandy gravel. At L2-SB01, the gravel is underlain by about 15 feet of hard, reddish brown, gravelly clay. Beneath the clay at L2-SB01 and beneath the gravel at L2-SB02 (at depths of 25 and 10.5 feet bgs, respectively) is moderately hard, severely weathered, volcanic rock. The upgradient boring (L2-SB03) encountered 3 feet of fill (brown, slightly clayey, sandy, gravelly silt/silty gravel), underlain by 4 feet of dense, brown, slightly sandy, gravelly, clayey silt, with gravel content increasing with depth. Relatively unweathered, hard rock (andesite) was encountered at a depth of about 7 feet in this boring. Logs of the borings are presented as Figures D-2 through D-4 in Appendix D.

No sheen, odor, or elevated PID readings were detected during field screening of soil samples from the borings, with the exception of PID readings for samples collected at and below the water table at L2-SB02. PID readings ranged from 0.2 to 4.4 parts per million (ppm) in soil samples collected from depths of 5 to 15 feet in this boring. These PID readings are relatively low and may be related to the moisture content of the soil samples.

6.2.3.2 Groundwater

The water table was encountered at depths of 2.6 to 2.9 feet bgs during drilling of the two downgradient soil borings. The lower part of the upper silty clay/clayey silt unit and the silty, sand/gravel unit in borings L2-SB01 (well L2-MW01) and L2-SB02 (well L2-MW02) were saturated, whereas the underlying clay and bedrock were moist, indicating the presence of a perched aquifer in this area. No groundwater was encountered in the upgradient boring during or immediately after installation; however, evidence of a wet season water table (iron staining) was seen at about 3 feet bgs. Groundwater levels were measured in the Landfill 2 wells on August 3, 1998 (Table 4-4), and again during groundwater sampling (August 4 and 6, 1998). These groundwater levels were similar to those measured during drilling. Upgradient well L2-MW03 was dry.

The estimated groundwater gradient in the Landfill 2 vicinity is generally to the south, toward Lacamas Creek, and ranges from 0.005 and 0.02 foot/foot, based on groundwater levels measured on August 3, 1998, in the Landfill 2 and Landfill 3 wells (Figure 6-1). Based on a southerly groundwater flow direction, monitoring well L2-MW02 appears to be located directly downgradient of Landfill 2, while well L2-MW01 may be in a more crossgradient location.

Another round of water level measurements was obtained on December 16, 1998. The water level in well L2-MW01 was more than a foot higher than that measured during August, and the

level in well L2-MW02 was more than one-half foot higher (see Table 6-1). Approximately one-half foot of water was present in the bottom of upgradient well L2-MW03 during December; however, there was insufficient volume to allow sampling. Using the new water level measurements, the direction of groundwater flow remained similar to that previously described.

PID screening of the headspace of each well casing did not indicate the presence of any VOCs, and no groundwater sheen or odor was noted during well development or groundwater sampling.

6.2.4 Analytical Results

6.2.4.1 Soil Gas Survey

Sixty-four soil gas samples were collected in the Landfill 2 area. The samples were analyzed for halogenated hydrocarbons and benzene, toluene, ethylene, and xylenes (BTEX) compounds by EPA Methods SW8010 and SW8020. These data were used as a screening tool to determine whether volatile constituents are present in and escaping from the landfill, rather than to provide a reliable quantitation of concentrations. Analytical results from this sampling were below the method detection limits for all soil gas samples with the exception of chloroform. Trace concentrations of chloroform were detected in two samples, 4 nanograms (ng) in sample L2-SG-40 and 6 ng in sample L2-SG-58. These trace concentrations of chloroform may be due to contamination from sampling or analytical procedures. The results of the soil gas sampling are presented in Appendix B.

6.2.4.2 Soil

One soil sample was collected from each of the three soil borings. The samples were analyzed for TPH, VOCs, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs)/pesticides, nitroaromatic and nitramine explosives, pentaerythritol tetranitrate (PETN), picric acid (PA), cyanide, total organic carbon (TOC), and priority pollutant metals. Results of these analyses are summarized in Table 6-2.

Analytical results for TPH, VOCs, SVOCs, PCBs/pesticides, explosive compounds (including PETN and PA), and cyanide were below the detection limit for all samples, except PETN in one sample. Sample L2-SB01-01 contained PETN at an estimated concentration of 0.22 mg/kg. No regulatory screening levels are available for PETN in soil.

Antimony, cadmium, lead, nickel, silver, and zinc were detected in all of the Landfill 2 soil samples, but at concentrations below the regulatory screening criteria. Arsenic, barium, beryllium, chromium, copper, and thallium were detected in all soil samples at concentrations exceeding one or more of the regulatory cleanup criteria for soils. However, only one of these metals exceeded the background levels. Copper was detected at a concentration of 134 mg/kg in sample L2-SB03-01 (from the upgradient soil boring); this slightly exceeds the background level of 114 mg/kg. Total organic carbon in all samples ranged from 0.36 mg/kg to 1.3 mg/kg.

6.2.4.3 Groundwater

Groundwater samples were collected from downgradient monitoring wells L2-MW01 and L2-MW02. The upgradient well was dry at the time of sampling in August 1998 and had too little water for sampling during a water level check in December 1998. A rinsate blank sample also was collected following sampling at well L2-MW02. All samples were analyzed for TPH, VOCs, SVOCs, explosive compounds (including PETN and PA), PCBs/pesticides, cyanide, and priority pollutant metals (total and dissolved). A summary of the analytical results is provided in Table 6-3. Groundwater field parameters measured at the time of sampling are presented in Table 6-1.

TPH, SVOCs, explosive compounds, and PCBs/pesticides were not detected in any of the samples. One VOC was detected in groundwater sample L2-MW02-01; naphthalene was detected at an estimated concentration below the regulatory criteria.

Arsenic, barium, chromium, copper, lead, nickel, selenium, thallium, and zinc all were detected in one or both of the groundwater samples. However, arsenic was the only metal detected at a concentration above regulatory screening levels. Both total and dissolved arsenic were detected at concentrations above the EPA Region 3 risk-based criterion (0.000045 mg/L) and the MTCA Method B (0.00005 mg/L) screening level in both samples. Neither of the samples exceeded the MCL of 0.05 mg/L for arsenic. Cyanide was detected at a concentration below regulatory levels in the rinsate blank sample. It was not detected in any of the monitoring well samples.

6.2.5 Discussion of Results

The approximate area of debris disposal was identified by geophysical surveying. The depth of the material could not be determined; however, some of the debris occurs at shallow depths, with metal observed protruding at the ground surface. Because groundwater was encountered in the site area at depths of only a few feet bgs, at least some of the debris at the Landfill 2 site can be expected to be in contact with groundwater. Therefore, contaminant migration via shallow groundwater is expected to be the primary release mechanism at this site. Contaminants from the landfill also may discharge to soil with subsequent transport to groundwater. Groundwater appears to occur under perched conditions at the site, and is assumed to flow toward and discharge to Lacamas Creek, located roughly 200 feet south of the landfill perimeter.

Results of subsurface soil sampling in soil borings downgradient of the landfill (with samples collected at the soil-groundwater interface) did not indicate the presence of any constituents at concentrations above the regulatory/risk-based screening criteria and background levels (where applicable). Copper was detected at a concentration above the lowest regulatory screening criterion and slightly exceeding the background concentration (but less than two times background) in a soil sample from the upgradient soil boring. Sampling of downgradient groundwater indicated the presence of elevated concentrations of arsenic only (at concentrations exceeding the risk-based criteria but below the MCL). The upgradient well was dry and could not be sampled. Elevated concentrations of arsenic have been detected in groundwater from

several wells (both upgradient and downgradient) at different sites at Camp Bonneville, and may be related to natural background.

6.3 LANDFILL 3

6.3.1 Site Characteristics

This former landfill is located southeast of the existing sewage lagoon, near Lacamas Creek, and approximately 300 feet southeast of Landfill 2 (Figure 6-1). According to the EBS, the site was described by the previous Camp Bonneville Facility Manager as having been used as a trash burial area from the mid- to late 1970s to the early to mid-1980s. The landfill trench reportedly was approximately 40 feet long by 12 feet wide by 8 feet deep, and ran north-south. Objects such as a refrigerator, a locker, wallboard, and paint cans were reportedly buried here. Soil was scraped from nearby and pushed onto the landfill, creating a broad mound that currently marks the location of the landfill. This site was assigned BRAC parcel number 5(7)HR(P).

The location of Landfill 3 is evident by the mound of soil in an otherwise fairly flat area on the Lacamas Creek floodplain. Lacamas Creek flows along the eastern and southern sides of the site. At its closest point, Lacamas Creek is approximately 20 feet east of the landfill area. The creek banks are nearly vertical with the top of the bank about four feet above stream level at the time of our field investigation (July 1998). Photographs of the site are provided in Appendix A.

6.3.2 Site Investigations

Tasks performed at this site included UXO avoidance work, geophysical surveying, performance of a soil gas survey, drilling and subsurface soil sampling, monitoring well installation, and groundwater sampling. The initial site characterization work was performed during the Phase 1 investigation. The drilling, well installation, and sampling tasks were performed during the Phase 3 investigation.

A UXO avoidance/screening survey was performed on December 9, 1997. A two-person crew of UXO specialists flagged magnetic anomalies to be avoided during subsequent investigation activities. The landfill and a large area surrounding the landfill were initially surveyed, and additional areas were surveyed, as needed, as the field work progressed. Numerous magnetic anomalies detected within the landfill area were likely due to the presence of buried metal debris at shallow depths.

An EM survey was performed in the Landfill 3 area on December 12, 1997. GPR equipment was not used because of the high natural ground conductivity and rough terrain. The methods and results of the geophysical survey are described in Appendix B.

A soil gas survey also was performed during December 1997. Eleven soil gas samplers were planted in and around the perimeter of the landfill area, as delineated by the geophysical survey. A grid pattern was used to select sample locations; however, many of the sample locations had to

be adjusted (and in some cases eliminated entirely) because of the presence of magnetic anomalies (possible UXO). The samplers were planted on December 16, 1997, and retrieved on December 30, 1997, by representatives of TEG. Locations of the soil gas samples are provided in Appendix B.

Five soil borings were drilled in the Landfill 3 area during July 1998. The borings were drilled to characterize the shallow subsurface conditions and to evaluate potential pathways for contaminant migration from the landfill. Each soil boring was initially advanced by the UXO specialists to a depth of approximately 5 feet bgs. The drilling rig was then moved over the hole, and drilling continued by the hollow-stem auger method.

One soil sample was collected (for chemical analysis) at or immediately above the water table in each soil boring to characterize the shallow groundwater pathway. Duplicate/split samples and MS/MSD samples were collected at location L3-SB02-01. Because the water table was shallow and safety provisions required the UXO specialists to advance the holes to depths of approximately 5 feet bgs using hand augers, soil samples for chemical analysis were collected from the hand auger rather than from split-spoon samplers advanced by the drilling rig.

The direction of groundwater flow was assumed to be to the east, southeast, and south, based on site topography and the proximity to Lacamas Creek. Of the four soil borings drilled in locations presumed to be downgradient of Landfill 3, two were originally planned to be used as wells. Following discussions with the on-site Corps representative, one additional downgradient boring was used for installation of a well, for a total of one upgradient (L3-MW04) and three downgradient monitoring wells.

The wells were developed on July 24 and 27, 1988. The wells were developed for approximately 4 hours each. During development, approximately 42, 39, 34, and 40 gallons of water were removed from wells L3-MW01, L3-MW02, L3-MW03, and L3-MW04, respectively. Groundwater samples were collected from the wells during August 3 through 6, 1998. A duplicate/split groundwater sample was collected from well L3-MW03. MS/MSD samples were collected from well L3-MW02.

6.3.3 Field Observations

A considerable amount of metallic debris (including corrugated metal sheets, pipes, drums, and wiring) was detected at and near the land surface; however, UXO-related debris was not observed. During the geophysical survey, the landfill area was found to generally coincide with the elevated mound of dirt at the site. The Landfill 3 area, as delineated by the geophysical survey, measured about 50 feet wide by 70 feet long. The approximate outline of the landfill is shown in Figure 6-1.

6.3.3.1 Soil

The soil profile in the Landfill 3 borings consists of a thin layer of alluvial and lacustrine soil over volcanic rock. The upper 5 feet of soil generally consists of brown, slightly sandy, slightly

clayey to clayey silt. This fine-grained soil is underlain by about 5 to 7 feet of brown to gray, slightly silty to silty, sandy gravel to a depth of about 9 to 11 feet. At L3-SB05 (the upgradient boring), the gravel was underlain by about 18 feet of hard, gray to reddish brown, silty clay. Beneath the clay at L3-SB05 (at 29 feet bgs) and beneath the gravel at the other Landfill 3 borings (at 9 to 12 feet bgs) hard, gray, highly weathered, volcanic rock was encountered. The lower portion of the upper silt unit and the silty, sandy gravel units were saturated, whereas the underlying clay and the weathered bedrock were moist, indicating the presence of perched groundwater. Logs of the borings are presented as Figures D-5 through D-9 in Appendix D.

No sheen, odor, or elevated PID readings were detected during field screening of soil samples from the Landfill 3 borings, with the exception of PID readings for two samples from below the water table at L3-SB04. PID readings of 3.3 and 0.5 ppm were measured in the 7.5- and 10-foot soil samples from this boring, respectively. These PID readings are relatively low and may be related to the moisture content of the soil samples.

6.3.3.2 Groundwater

The water table was encountered between about 3 and 5 feet bgs during drilling, and at similar levels after the wells had been installed and developed. This shallow groundwater is perched above rock or clay within the relatively thin alluvial sandy gravel. Groundwater levels were measured in the Landfill 3 wells on August 3, 1998 (Table 4-4), and again during groundwater sampling (August 3 through 6). The estimated groundwater gradient in the Landfill 3 vicinity is generally to the southeast, toward Lacamas Creek, and ranges between about 0.007 and 0.01 foot/foot, based on groundwater levels measured on August 3, 1998, in the Landfill 2 and Landfill 3 wells (Figure 6-1).

Another round of water level measurements was obtained on December 16, 1998. Increases in water levels in the four monitoring wells ranged from 0.86 to 1.26 feet (see Table 6-1). The December water level measurements do not appear to significantly affect the direction of groundwater flow in the site area.

Based on a groundwater flow direction to the southeast, well L3-MW01 appears to be directly downgradient of Landfill 3. However, based on the topographic mound created by Landfill 3, and the fact that Lacamas Creek wraps around the site to the east and south, infiltration and precipitation at the site likely migrates somewhat radially toward the creek. Wells L3-MW02 and L3-MW03 may be either downgradient or somewhat crossgradient of the landfill.

PID screening of the headspace of each well casing did not indicate the presence of VOCs. No groundwater sheen or odor was noted during well development or groundwater sampling.

6.3.4 Analytical Results

6.3.4.1 Soil Gas Survey

Eleven soil gas samples were collected in the Landfill 3 area to screen for halogenated hydrocarbons and BTEX compounds. The analyses were performed by EPA Methods SW8010

and SW8020. Analytical results for the soil gas samples were below the detection limits for all analytes in every sample. Copies of the laboratory reports are included in Appendix B.

6.3.4.2 Soil

Five soil samples and one duplicate/split sample were collected from the water table interface in soil borings at Landfill 3. The samples were analyzed for TPH, VOCs, SVOCs, PCBs/pesticides, nitroaromatic and nitramine explosives, PETN, PA, cyanide, TOC, and priority pollutant metals. Results of these analyses are summarized in Table 6-2 and discussed below.

Analytical results for TPH, VOCs, SVOCs, PCBs/pesticides, explosive compounds (including PETN and PA), and cyanide were below the detection limit for all samples. Antimony, cadmium, lead, nickel, selenium, silver, and zinc were detected in some or all of the samples, but at concentrations below regulatory screening criteria. Arsenic, barium, beryllium, chromium, copper, and thallium were detected in most or all soil samples at concentrations exceeding one or more of the regulatory screening criteria; however, none of these metals exceeded the background levels. TOC in all samples ranged from 0.62 mg/kg to 1.3 mg/kg.

6.3.4.3 Groundwater

Four groundwater samples and one duplicate sample were collected from the monitoring wells at Landfill 3. All samples were analyzed for TPH, VOCs, SVOCs, nitroaromatic and nitramine explosives, PETN, PA, PCBs/pesticides, cyanide, and priority pollutant metals (total and dissolved). A summary of the analytical results is provided in Table 6-3. Groundwater field parameters measured at the time of sampling are presented in Table 6-1.

TPH, SVOCs, explosive compounds (including PETN and PA), cyanide, and PCBs/pesticides were not detected in any of the samples. Methylene chloride was detected in samples L3-MW01-01 and L3-MW02-01 at concentrations below the regulatory screening criteria. Methylene chloride is a common laboratory contaminant and was also detected in the method blank for this analysis. Naphthalene was detected in one sample (L3-MW02-01) at an estimated concentration below the regulatory screening criteria.

Arsenic, barium, chromium, copper, lead, nickel, selenium, thallium, and zinc were detected in some or all of the groundwater samples. Of these, only arsenic was detected at concentrations above regulatory screening criteria. Arsenic was detected in both total and dissolved samples at concentrations above the EPA Region 3 level (0.000045 mg/L) and the MTCA Method B (0.00005 mg/L) level in all three of the downgradient well samples (L3-MW-01-01, L3-MW02-01, and L3-MW-03-01) and the duplicate. The arsenic concentrations detected ranged from 0.00086 mg/L (estimated) to 0.0035 mg/L. None of the samples exceeded the MCL of 0.05 mg/L for arsenic. Arsenic was not detected in the upgradient groundwater sample.

6.3.5 Discussion of Results

The approximate area of debris disposal was identified by geophysical surveying and appears to roughly correspond with the mounded area at the site. The depth of the material could not be

determined; however, some of the debris occurs at shallow depths, with metal observed on and protruding from the ground surface. Because groundwater was encountered in the site area at depths of only a few feet bgs, at least some of the debris at the Landfill 3 site can be expected to be in contact with groundwater. Therefore, contaminant migration via shallow groundwater is expected to be the primary release mechanism at this site. Contaminants from the landfill also may discharge to soil with subsequent transport to groundwater. Groundwater appears to occur under perched conditions at the site, and is assumed to flow toward and discharge to Lacamas Creek, located immediately south and east of the landfill area.

Results of subsurface soil sampling (with samples collected at the soil-groundwater interface) did not indicate the presence of any constituents at concentrations above the regulatory/risk-based screening criteria and background levels (where applicable). Sampling of downgradient groundwater indicated the presence of elevated concentrations of arsenic only (at concentrations above the risk-based criteria but below the MCL). Arsenic was not detected in groundwater from the upgradient monitoring well. Elevated concentrations of arsenic have been detected in groundwater from several wells (both upgradient and downgradient) at different sites at Camp Bonneville, and may be related to natural background.

6.4 BURN AREA

6.4.1 Site Characteristics

The former Burn Area is located immediately north of Landfill 3, to the southeast of the existing sewage lagoon (Figure 6-1). A pile of wooden debris approximately 20 feet long by 15 feet wide marking the site was removed in June 1997. The area reportedly was used infrequently to burn wood and debris, although there is no record of the length of use or list of materials burned (Woodward-Clyde, 1996). This area has apparently not been used for burning material since the mid-1980s. According to the Camp Bonneville Facility Manager, debris had been piled on the site for three or four years, before its removal in June 1997. Photographs of the site are provided in Appendix A.

6.4.2 Site Investigations

A UXO avoidance/screening survey was performed across the site area during the debris removal. Soil sampling locations were rechecked by the UXO specialists before sampling.

Surface and near-surface soil samples were collected from five locations in and adjacent to the former Burn Area on December 16 and 17, 1997 (Figure 6-1). The samples were collected to evaluate the potential for contamination resulting from past disposal and burning activities. Three sampling locations (BA-SS-03, BA-SS-04, and BA-SS-05) were within the former Burn Area. The other two locations (BA-SS-01 and BA-SS-02) were upslope and downslope of the Burn Area, respectively. Two samples were collected from each location to assess the vertical extent of contamination: one from the 0 to 1-foot bgs interval, and one from the 1- to 2-foot bgs

interval. Duplicate/split samples were collected with sample BA-SS-03-01. MS/MSD samples were collected with sample BA-SS-05-01. Samples for duplicates, splits, and MS/MSDs were co-located but homogenized together, with the exception of those samples collected for volatile analyses.

6.4.3 Field Observations

The debris had been removed prior to initiation of the field investigation, leaving the area accessible for soil sampling. Soils encountered at the site generally consisted of stiff, reddish, silty clay with occasional debris, including wood, charcoal, and glass. The upslope sample location (BA-SS-01) filled with water at a depth of about 1.2 feet bgs, and the deeper of the two samples from this location was saturated. PID readings were less than 1 ppm for all samples. Surface/near-surface soil sampling logs are presented in Appendix C.

6.4.4 Analytical Results

Ten soil samples and one duplicate/split were collected from five locations (two depths each) in the former Burn Area. Each sample was analyzed for TPH, VOCs, SVOCs, PCBs/pesticides, nitroaromatic and nitramine explosives, PETN, PA, and priority pollutant metals. A summary of the analytical results is provided in Table 6-4.

TPH, SVOCs, PCBs/pesticides, and explosive compounds (including PETN and PA) were not detected in any of the samples. VOCs were detected (all at estimated concentrations) in three of the samples at levels below regulatory screening criteria. The VOCs detected in sample BA-SS-05-02 include xylenes, toluene, and acetone. Toluene and xylenes also were detected in sample BA-SS-02-02 (downslope), and xylenes were detected in sample BA-SS-01-01 (upslope).

Antimony, cadmium, lead, nickel, selenium, silver, zinc, and mercury were detected at concentrations below regulatory screening criteria in some or all of the samples. Arsenic, beryllium, chromium, and copper were detected in all samples at concentrations exceeding one or more of the regulatory screening criteria. However, these concentrations did not exceed the background levels. Thallium was detected in four samples; concentrations in two of these samples exceeded the MTCA B groundwater protection criteria. Thallium in one sample (0.29 mg/kg in sample BA-SS05-01) also slightly exceeded the background level of 0.27 mg/kg.

6.4.5 Discussion of Results

The Burn Area site is located immediately north of Landfill 3 and approximately 50 feet west of Lacamas Creek. Debris at the site was removed prior to the field investigation. Because the source materials were above ground, any contaminants released from materials stored or burned at the site would either enter underlying soil or migrate via surface water runoff. Because runoff from the site appears to pond on or immediately adjacent to the site, direct runoff to Lacamas Creek appears unlikely. Contaminated surface runoff would likely impact nearby soil.

Surface and near-surface soil samples were collected from within the former Burn Area, as well as upslope and downslope of the site. Only one constituent, thallium, in one sample, was detected at a concentration above the regulatory/risk-based screening criteria and background (but less than two times background) in one sample collected at the ground surface. A sample collected 1 foot beneath this sample did not contain elevated thallium.

6.5 FORMER BUILDINGS 1962 AND 1983

6.5.1 Site Characteristics

Buildings 1962 and 1983 were located near the southeastern corner of the Camp Bonneville cantonment area (Figure 6-2). They were burned in place, and the burned debris was removed to an unknown location, leaving no visible trace of the footprints of the buildings. Building 1962 was a 9-foot-wide by 12-foot-long storage shed used to store fire hoses, and Building 1983 was a 10-foot-wide by 40-foot-long structure used as a stage and outdoor theater. Both buildings were constructed in the 1930s with wooden frame walls, wooden floors, wooden post/concrete pillar foundations, and rolled composition roofs. Based on the age and type of construction, it is reasonable to suspect that lead-based paint may have been used in the buildings. Lead from the paint could have been released to the soils over the life of the buildings and when they were burned. Asbestos and semivolatiles may also have been present in the composition roofing materials and other building materials. Photographs of the site are provided in Appendix A.

6.5.2 Site Investigations

A magnetometer was used in an attempt to locate the footprints of the former buildings. On February 25 and 26, 1998, surface soil samples were collected from five locations within the suspected footprints of the former buildings, and from five additional locations within 50 feet of the suspected footprint of the former buildings (Figure 6-2). The soil samples were collected to determine if soil contamination resulted from the building use or destruction. Samples BD-SS-01 through BD-SS-05 were located outside of the building footprints. One sample was collected from each of these locations, from the 0 to 1-foot bgs interval. Sample locations BD-SS-06 and BD-SS-07 were within the Building 1962 footprint, and sample locations BD-SS-08 through BD-SS-10 were within the Building 1983 footprint. Two samples were collected from each of the sample locations within the former building areas: one from the 0 to 1-foot depth interval, and one from 1 to 2 feet bgs. Duplicate/split samples and MS/MSD samples were collected from location BD-SS-06-01.

6.5.3 Field Observations

The area where Buildings 1962 and 1983 were located is a grassy field with no obvious evidence of the former buildings. Using available maps, the UXO specialists conducted a magnetometer survey of the area and were able to identify evidence of what may be the former building areas.

This evidence included nails and pieces of wood in areas that corresponded to the mapped locations of the former buildings.

Soils encountered at the site consisted of stiff, reddish-brown, silty clay with some fine sand. The soil exhibited low to medium plasticity and commonly contained roots. The root mat was thick in many locations; therefore, sampling began at a depth of 1 to 3 inches bgs in most surface soil sample areas. Surface and near-surface soil sampling logs are presented in Appendix C.

PID measurements for all surface samples were less than 1 ppm. At sample locations BD-SS-08 and BD-SS-09, soil samples were collected in resealable plastic bags for PID headspace readings. Results of these readings were below 1 ppm. However, when the PID tip was placed down each sample hole, the readings were 7.2 and 12.3 ppm, respectively. No visible evidence of contamination was observed in the samples collected at these locations. A natural organic odor was noted in the soil, and the PID readings likely are due to natural organics and/or moisture.

6.5.4 Analytical Results

Fifteen soil samples and one duplicate/split sample were collected from ten locations at the Former Buildings 1962 and 1983 site. Each sample was analyzed for SVOCs, asbestos, and lead. A summary of the sample results is provided in Table 6-5. No SVOCs or asbestos were detected in any of the samples. Lead was detected in all fifteen samples and the duplicate sample; however, none of the concentrations detected exceed the regulatory or risk-based screening criteria for lead.

6.5.5 Discussion of Results

Buildings 1962 and 1983 burned down and were removed from the site an unknown number of years ago. Because the source materials were above ground, any contaminants released from the buildings or during combustion of the buildings would either enter underlying soil or migrate via surface water runoff. Contaminated surface runoff would likely impact nearby soil.

Surface and near-surface soil samples were collected from within the apparent footprints of Former Buildings 1962 and 1983, as well as upslope and downslope of the former buildings. No constituents were detected at concentrations above the regulatory/risk-based screening criteria in the soil samples.

6.6 DRUM DISPOSAL AREA

6.6.1 Site Characteristics

A suspected drum burial area was identified in May 1996 by an anonymous caller to the Camp Bonneville Facility Manager. The caller, who claimed to be a former employee at the camp, reported that pesticides, paints, and solvents were disposed of in this area (and in the Paint and

Solvent Disposal Area, described in Section 6.7). The Drum Disposal Area reportedly was located south of the Camp Killpack cantonment, east of the gravel road leading south from the main east-west roadway through the facility (Figure 2-1). Following the anonymous call, the Facility Manager located suspected buried metal in this area using a metal detector. Photographs of the site are provided in Appendix A.

6.6.2 Site Investigations

Tasks performed at this site included UXO avoidance work, geophysical surveying, and subsurface soil sampling. A UXO avoidance/screening survey was performed by a two-person crew. A large area (including access to the site) was initially surveyed, and magnetic anomalies were flagged and avoided during subsequent activities. The UXO specialists surveyed additional areas, as needed, as the field work progressed.

An EM survey of the area was performed on December 13, 1998, to attempt to identify and delineate the extent of any buried drums. GPR was not used at this site because of the dense vegetation (brambles), the irregular land surface, and the presence of ponded water. The results of the geophysical survey (Appendix B) indicated that the extent of the buried material was very limited both laterally and vertically. Two soil borings were advanced adjacent to the area identified to collect soil samples for evaluation of the potential for contamination from the drums.

Borings DB-SB01 and DB-SB02 were advanced immediately north and south of the disposal area, respectively, on July 22, 1998 (Figure 6-3). The UXO contractors advanced the borings to a total depth of 5 feet bgs. Downhole magnetometer readings were obtained every 2 feet. Refusal of the hand auger was encountered at shallow depth because cobbles were present. Therefore, a shovel was used to excavate a large hole to a depth of approximately 4 feet bgs at each location. A hand auger was then used to collect the samples from the 4 to 5 feet bgs interval (approximately 1 foot below the estimated depth of the buried drums). Soil samples from various depths were screened using a PID during excavation of the borings/holes.

6.6.3 Field Observations

The Drum Disposal Area site floods during the wet season and is typically covered by several inches of water during the winter months. This flooding during the winter and spring of 1997/1998 delayed the field investigation until the area was sufficiently dry for site access.

The geophysical survey identified a small area at shallow depth that likely contains one or two drums (see Figure 6-4). The top of one drum is exposed at the surface. During an attempt at sampling, part of another buried drum (or possibly the same drum if it is severely crushed) was located approximately 1 foot northeast of the exposed drum top.

Soils encountered in the two borings included 3 to 4 feet of fill (brown, slightly sandy, gravelly, clayey silt with scattered cobbles) underlain by mottled brown and gray, clayey silt to silty clay

with scattered dark organics. No groundwater was encountered. All PID readings for the borings were less than 1 ppm. No visible staining or odor was observed during soil sampling. Logs of the borings are presented as Figures D-10 and D-11 in Appendix D.

6.6.4 Analytical Results

A wide range of analyses were performed on the soil samples from this site because of the unknown contents (if any) of the buried drums. Each soil sample was analyzed for TPH, VOCs, SVOCs, PCBs/pesticides, nitroaromatic and nitramine explosives, PETN, PA, and priority pollutant metals. The results of these analyses are summarized in Table 6-6.

Both samples contained unknown hydrocarbons (quantitated based on diesel range) at concentrations below the regulatory screening criteria. No SVOCs, PCBs/pesticides, or explosive compounds were detected in either of the samples. Results of the PA analyses were rejected because the laboratory QC data did not meet the required criteria; however, no evidence of the presence of explosives was found at the site. Sample DB-SB01-01 contained several VOC constituents at concentrations below regulatory screening criteria. The VOCs detected include acetone, methyl ethyl ketone, ethylbenzene, xylenes, naphthalene, 2-hexanone, isopropyltoluene, isopropylbenzene, n-propylbenzene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, and tert-butylbenzene.

Cadmium, lead, nickel, silver, and zinc were detected at concentrations below the regulatory screening criteria in both samples. Antimony, arsenic, barium, beryllium, chromium, and copper exceeded regulatory screening criteria in one or both samples. The arsenic, beryllium, and chromium concentrations did not exceed background concentrations. However, the detected concentrations of antimony in sample DB-SB01-01, barium in sample DB-SB02-01, and copper in sample DB-SB02-01 exceeded both MTCA B groundwater protection criteria and the background concentrations.

6.6.5 Discussion of Results

The Drum Disposal Area, as identified by geophysical surveying, appears to be very small and likely includes only one or two drums. A small portion of one drum is exposed at the ground surface; therefore, the drums appear to extend only a few feet bgs. Contaminants released from the drums would be expected to enter underlying soil. Contaminants in subsurface soil may migrate to shallow groundwater. Groundwater was not encountered during sampling at this site in July 1998 (to a depth of 5 feet bgs); however, groundwater is assumed to flow toward Lacamas Creek, located approximately 400 feet southeast of the site.

Two soil samples were collected from locations immediately adjacent to the Drum Disposal Area, at depths assumed to be just below the base of the drums. Antimony, barium, and copper were detected in soil at concentrations above background and MTCA Method B groundwater protection criteria; however, they did not exceed the risk-based criteria for soil. TPH and several VOCs were detected, although at concentrations below the screening levels.

6.7 PAINT AND SOLVENT DISPOSAL AREA

6.7.1 Site Characteristics

The suspected Paint and Solvent Disposal Area was identified in May 1996 by an anonymous caller to the Camp Bonneville Facility Manager. The caller, who claimed to be a former employee at the camp, reported that pesticides, paints, and solvents were disposed of in this area and in another nearby location (the Drum Disposal Area, discussed in Section 6.6). The Paint and Solvent Disposal Area was reportedly located south of the Camp Killpack cantonment, in an open area where a tractor shed currently exists (Figure 2-1). Following the anonymous call, the Facility Manager used a metal detector in this area to locate suspected buried metal. Photographs of the site are provided in Appendix A.

6.7.2 Site Investigations

Tasks performed at this site included UXO avoidance work, geophysical surveying, and subsurface soil sampling. A UXO avoidance/screening survey was performed by a two-person crew of UXO specialists. A large area was initially surveyed, and magnetic anomalies were flagged and avoided during subsequent activities. The UXO specialists surveyed additional areas, as needed, as the field work progressed.

An EM survey was performed in the disposal area to attempt to identify and delineate the extent of any buried drums or metal debris. The results of the geophysical survey, presented in Appendix B, indicated that two very small areas contain buried (or partially buried) material. Based on this distribution, two borings were drilled at each location to collect soil samples to evaluate the potential for contamination.

Two soil borings were advanced adjacent to each of the identified disposal areas. The UXO contractors advanced the borings to the total depths. Downhole magnetometer readings were obtained every 2 feet. Refusal of the hand auger was encountered at shallow depths in all boring locations because of cobbles; therefore, a shovel was used to excavate a large hole to the top of the sampling interval. A hand auger was then used to collect the samples from the desired interval. One soil sample was collected from each of the four soil borings (PD-SB01 through PD-SB04). In addition, a duplicate sample was collected from one location (PD-SB03). The samples were collected from depths estimated to be just below the base of the debris. Soil samples were screened using a PID during excavation of the borings/holes.

6.7.3 Field Observations

Results of the EM survey indicated two separate areas of concern. One was located at the edge of the trees at the location identified as the Paint and Solvent Disposal Area on Figure 6-4. This area appeared to be limited in size (roughly 10 feet by 15 feet or less). Materials in this location appeared to be buried at a shallow depth. In addition, a considerable amount of metallic debris (including pipes and wiring) was observed at the ground surface at and around this area.

Unidentified materials (possibly shallow buried metallic debris) caused positive responses from the UXO magnetometers, preventing subsurface access in many areas around the geophysical anomaly. Soil samples at this site were collected as close as possible to the apparent subsurface geophysical anomaly. The second debris area was in the trees, in the approximate location identified as the Paint Can on Figure 6-4. The only debris identified at this location was a partially buried 5-gallon paint can.

The soils encountered in the borings at the larger of the two disposal areas consisted of brown, slightly sandy, gravelly, clayey silt, with scattered cobbles. PID readings for these borings were all less than 1 ppm. The borings near the paint can encountered brown, gravelly, sandy silt to silty sand. PID readings for these borings ranged from 1 ppm in sample PD-SB04-01 to 3 ppm in sample PD-SB03-01. Organic matter was generally present in the upper 2 to 3 feet of each of the four borings. No staining or odors were detected during the field investigation activities in either area at this site. Groundwater was not encountered in any of the borings. Logs of the borings are presented as Figures D-12 through D-15 in Appendix D.

6.7.4 Analytical Results

All soil samples collected at the Paint and Solvent Disposal Area were analyzed for TPH, VOCs, SVOCs, PCBs/pesticides, nitroaromatic and nitramine explosives, PETN, PA, and priority pollutant metals. Results of these analyses are summarized in Table 6-6 and discussed in this section. (The laboratory referred to these samples as "PB" rather than "PD"; therefore, the laboratory reports and data summary tables reflect this different designation.)

Unknown hydrocarbons were detected at concentrations below MTCA Method A criteria in all four samples and the duplicate. A review of the chromatogram for the sample with the highest reported unknown hydrocarbon concentration (sample PD-SB04-01 at 160 mg/kg) indicated that the peaks generally fall within the diesel range but extend up to C_{26}. The substance detected in this sample resembles a weathered diesel or possibly a diesel-oil mixture.

No VOCs, SVOCs, PCBs/pesticides, or explosive compounds were detected in any of the samples. Results of the PA analyses were rejected for four of the samples because the laboratory QC data did not meet the required criteria; however, no evidence of the presence of explosives was found at the site.

Antimony, cadmium, lead, nickel, silver, and zinc were detected in some or all of the samples but at concentrations below the regulatory screening criteria. Arsenic, barium, beryllium, chromium, and copper were present in most or all samples at concentrations exceeding one or more of the regulatory levels; however, none of the concentrations exceeded the background levels.

6.7.5 Discussion of Results

Results of geophysical surveying in the Paint and Solvent Disposal Area indicated the presence of two small debris areas: one apparently shallow debris burial area and one 5-gallon paint can partially exposed at the ground surface. Groundwater was not encountered during sampling at this site in July 1998 (to a depth of 4 feet bgs).

Contaminants released from the debris would be expected to enter underlying soil. Four soil samples were collected from locations adjacent to the two debris areas, at depths assumed to be just below the base of the debris. No constituents were detected at concentrations above the regulatory/risk-based screening criteria and background levels (where applicable) in the soil samples.

6.8 MAINTENANCE PIT

6.8.1 Site Characteristics

The Maintenance Pit is located beneath the concrete floor slab under the west end of Building 4475, in the Camp Killpack cantonment (Figure 6-5). Building 4475 is currently used as the Camp Bonneville shop office. This building was identified in the EBS as BRAC parcel number 12(7)PR(P)/HR(P). The Maintenance Pit reportedly was an unlined excavation; the exact size, depth, and location are not known. The pit may have received vehicle fluids, such as gasoline, waste oil, lubricants, and antifreeze, as well as solvents, for an unknown period of time. In addition, pesticides may have been handled in front of the building, according to the EBS.

Building 4475 and the Maintenance Pit are bounded by Wash Rack No. 1 and a small stream to the west, a gravel drive and storage buildings to the north, and a ditch and the main road to the south. The building extends east of the Maintenance Pit area to a former UST location, which was recently remediated. A heating oil AST is located along the front (north) wall of the building. A chain link fence surrounds the entire shop office area, including the wash rack, the Hazardous Material Accumulation Point, and a number of smaller buildings. The fence runs between Building 4475 and the ditch to the south. Numerous underground and aboveground utilities run through the area immediately west of the building. The surrounding ground surface is a mix of gravel (to the north and south) and soil (to the west). Much of this area appears to have been filled to provide a level work area.

During performance of the EBS, stressed vegetation and stained (red) soil were reported on the south side of Building 4475. Stressed vegetation was still evident during a site visit in October 1997. The land surface in this area is primarily gravel. Potential causes of the vegetative stress include erosion caused by runoff from the building roof, contamination related to the Maintenance Pit, metals contamination from roof runoff, or other unknown factors. Photographs of the site are presented in Appendix A.

6.8.2 Site Investigations

An attempt was made to advance soil borings at three locations in the Maintenance Pit area during late July and early August 1998. One soil boring (MP-SB01) was drilled on the northeast side of the building, near the front door. Boring MP-SB01 was drilled and sampled to 11.5 feet bgs, using a hollow-stem auger drilling rig and split-spoon sampler. Three soil samples were collected from boring MP-SB01 for laboratory analysis. Samples from boring MP-SB01 were not analyzed for PCBs/pesticides as originally planned. Therefore, a second boring (MP-SB01A) was drilled and sampled adjacent to the original boring in November 1998. Boring MP-SB01A was advanced and sampled using a GeoProbe™ sampling system. Samples were collected from this boring for PCB/pesticide analyses only.

Boring MP-SB02 was attempted inside of the shop office building at the Maintenance Pit location. A hole was cut in the concrete floor, and a hand auger was used to attempt to dig down to the floor of the pit. No samples were collected from boring MP-SB02, because rubble that had apparently been placed in the pit when it was abandoned prohibited drilling and sampling.

Boring MP-SB03 was drilled and sampled behind (south of) the building. Because access was limited, a GeoProbe™ sampling system was used. Three soil samples were collected from this boring for laboratory analyses: at the ground surface, starting at 1.5 feet bgs, and starting at 3.5 feet bgs. Logs of the borings are presented as Figures D-16 through D-18 in Appendix D.

6.8.3 Field Observations

No evidence of contamination (sheen, odor, or PID readings above 0 ppm) was identified in the samples from boring MP-SB01. Fill soils (0 to 2 feet bgs) at this location consist of very dense, brown, silty, sandy gravel to slightly sandy, clayey, silty gravel. From 2 to 5 feet bgs, the soil consists of medium stiff, gray, slightly sandy, clayey silt with organics. From 5 to 6.5 feet bgs, a medium dense, brown, silty, clayey gravel is present. The gravel is underlain by hard, mottled brown and gray, silty clay/clayey silt to the bottom of the boring (11.5 feet bgs). Soils were moist, except between 4 and 6.5 feet bgs, where they were saturated. In adjacent boring MP-SB01A, a slight petroleum hydrocarbon-like odor was detected in the soil sample collected from 3.5 to 5.5 feet bgs, at the approximate depth of the perched water table. PID readings were not obtained during sampling in this boring, because they had been recorded during sampling in the adjacent boring. However, the petroleum hydrocarbon-like odor was not observed during drilling in boring MP-SB01.

Concrete rubble in the Maintenance Pit, coupled with the building and concrete floor constructed above it, prohibited access to the bottom of the pit for soil sampling. Boring MP-SB02, which was advanced by hand inside the pit, encountered fill to the bottom of the boring (3.8 feet bgs). Concrete fence posts, along with dirt and rocks, were a primary component of the fill materials encountered. As a result, the boring had to be drilled at an angle from vertical. This boring encountered what appeared to be a retaining wall constructed of railroad ties (probably the side of the pit), and could not be advanced through this material. The presence of creosote-soaked

wood fibers collected from the railroad ties resulted in a PID reading of 16 ppm in one sample. Groundwater was not encountered at this location.

PID readings were less that 1 ppm in soils above 3.5 feet bgs in boring MP-SB03. Solvent-like odors and elevated PID readings were noted starting at 3.5 feet bgs and continuing to the bottom of the boring at 5.5 feet bgs. PID readings up to 220 ppm were obtained in soil collected from this interval. The upper soils at this location consisted of about 4.5 feet of probable fill (brown to gray, slightly sandy to sandy, clayey, silty, cobbly gravel, with scattered organics below 3.6 feet). From 4.5 to 5.5 feet bgs, the soils consisted of grayish brown, gravelly, clayey silt. The presence of cobbles and large gravel prevented deeper sampling in this location. No groundwater was encountered in this boring.

6.8.4 Analytical Results

Six soil samples were collected from two soil borings at the Maintenance Pit site. All samples were analyzed for TPH, SVOCs, PCBs/pesticides, and priority pollutant metals. Subsurface samples were also analyzed for VOCs. The results of these analyses are summarized in Table 6-7 and described in this section.

Unknown hydrocarbons were detected in four of the six soil samples, with two of the samples (MP-SB01-01 and MP-SB03-03) containing concentrations of unknown hydrocarbons (quantitated as diesel-range) above the MTCA Method A cleanup level. MP-SB01-01 (collected at the ground surface) had an estimated TPH concentration of 210 mg/kg, which is just over the MTCA Method A level of 200 mg/kg for diesel. Sample MP-SB03-03 (collected starting at 3.5 feet bgs) had an estimated TPH concentration of 1,000 mg/kg, which is five times the MTCA Method A cleanup level for diesel. A review of the chromatogram for sample MP-SB01-01 indicated that the petroleum hydrocarbons detected eluted in the heavier end of the diesel range (C_{16} to C_{40}). This may be a weathered diesel-oil mixture or a weathered oil-based product. Sample MP-SB03-03 primarily contained compounds that eluted in the C_6 and C_7 range (lighter than diesel). From the chromatogram, it appears that this compound is similar to a solvent, such as stoddard solvent, or a thinner-type product, since solvents and thinners produce chromatograms with a series of peaks that elute in a very narrow range with few peaks found before or after the concentration of primary peaks.

Several VOCs were detected at concentrations below regulatory screening criteria in samples MP-SB01-02 and MP-SB03-03. Vinyl chloride was detected in sample MP-SB03-03 at an estimated concentration of 0.038 mg/kg, which exceeds the MTCA Method B groundwater protection criterion of 0.0023 mg/kg.

Two SVOCs were detected in sample MP-SB03-01, and one was detected in sample MP-SB03-03. Diethyl phthalate and bis(2-ethylhexyl)phthalate were the only SVOCs detected; concentrations of both compounds were below the screening levels. Both of these compounds are common laboratory contaminants.

No PCBs were detected in any of the soil samples; however, the detection limits for PCBs in surface soil sample MP-SB01A-01 were elevated above several of the screening criteria. No PCBs were detected in underlying sample MP-SB01A-02 (at the project-specified detection limit). Pesticides were detected in samples from two borings. Seven pesticides were detected in the shallow soil sample (MP-SB01A-01) from boring MP-SB01A, including 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, endrin, endosulfan sulfate, alpha chlordane, and gamma chlordane. Concentrations of five of these compounds exceeded the MTCA Method B groundwater protection criteria. The reported concentration of 4,4'-DDT also equaled the MTCA Method A criterion of 1,000 micrograms per kilogram (µg/kg). No screening criteria are available for endosulfan sulfate. Three pesticides (4,4'-DDE, 4,4'-DDD, and 4,4'-DDT) were also detected in the middle soil sample (MP-SB01A-02) from this boring, but at concentrations below all screening criteria. One pesticide (alpha chlordane) was detected in sample MP-SB03-03, but at a concentration below the regulatory screening criteria.

Arsenic, barium, beryllium, chromium, and thallium were detected in some or all samples at concentrations above one or more of the screening criteria; however, none of these metals exceeded the background levels. Copper and lead were detected at concentrations above both the regulatory and background screening criteria. Copper was detected in sample MP-SB01-03 at 149 mg/kg, above the background concentration of 114 mg/kg; this exceeds the MTCA Method B groundwater protection criterion. Lead was detected in sample MP-SB03-01 at a concentration of 633 mg/kg, which exceeds the MTCA Method A and EPA Region 3 regulatory levels and the background level.

6.8.5 Discussion of Results

Several areas of potential concern were identified at the Maintenance Pit site, including a possible pesticide-handling area in front of the shop office building, an area of stained soil behind the building, and the belowground vehicle maintenance pit (under the existing building). In addition, aboveground vehicle maintenance and above- and belowground fuel handling activities have occurred in the site area. The depth of the maintenance pit bottom could not be determined, and sampling beneath the pit was not possible because of access constraints. Perched groundwater was encountered at a depth of approximately 4 to 6.5 feet bgs in one boring drilled during July 1998.

Contaminant migration via soil is expected to be the primary release mechanism at the site. Surface and subsurface soil samples were collected from areas in front of and behind the building. Results of surface soil sampling and analysis indicated the presence of TPH and pesticides in soil in front of the building, and lead in soil behind the building, at concentrations above the screening levels. Contaminants detected at concentrations exceeding the screening levels in deeper soil samples include TPH and one VOC (vinyl chloride) in soil behind the building, and a slightly elevated concentration of copper (above background but below two times background) in one soil sample from in front of the building. PCBs were not detected at the site; however, because of elevated analytical detection limits in one soil sample, their presence can not be ruled out in surface soil in front of the shop office.

Contaminants detected in surface soil may migrate via surface water runoff to the small stream located west of the site. Contaminants in soil also may migrate to groundwater. Based on surrounding topography, groundwater from the site is assumed to flow generally to the south, potentially discharging to the nearby small stream.

Potential exposure routes include ingestion and dermal contact with contaminated soil, groundwater, surface water, and sediments. Potential receptors for contaminants detected at this site include site workers and visitors, and terrestrial and aquatic biota.

6.9 WASH RACK NO. 1

6.9.1 Site Characteristics

The Wash Rack No. 1 site is located immediately west of the shop office building (Building 4475) in the Camp Killpack cantonment (Figure 6-5). The wash rack was used for vehicle washing, reportedly between approximately 1978 and 1994 (Woodward-Clyde, 1996). The wooden wash rack structure remains, and consists of a two-track vehicle ramp. This site was initially identified as a concern during an environmental compliance inspection because it did not drain to an oil-water separator. Instead, wash water was discharged via uncontrolled overland flow to a nearby ditch (Woodward-Clyde, 1996). Potential contaminants at the Wash Rack No. 1 site include vehicle fluids, such as gasoline, waste oil, lubricants, and antifreeze, as well as solvents that may have been used during cleaning activities.

Except for a 1-inch thickness of asphalt at the extreme north end of the wash rack, the site is not paved and is covered with grass. The wash rack site is bounded by gravel (with minor asphalt) driving surfaces to the north and west. To the east of the site are a culvert and small stream, and Building 4475 (which includes the former Maintenance Pit). The wash rack structure abuts the chain-link fence that surrounds the shop office area.

Most of the wash water discharge from the site would have flowed to the unnamed stream that crosses the site. The stream emerges from a culvert located below the gravel fill pad, between the shop office building and the wooden ramps of the wash rack. It flows aboveground for about 15 feet before entering another culvert running southward under the main road. A ditch that runs along the north side of the road also joins the stream and runs under the road through the same culvert. The wash rack site slopes downward to the east and south, toward the stream and ditch, respectively. Photographs of the site are provided in Appendix A.

6.9.2 Site Investigations

Surface soil samples (WR-SS-01-01 and WR-SS-02-01) were collected on February 27, 1998, from two locations at the wash rack to evaluate potential contamination from the facility. Soil sampling logs are presented in Appendix C. One soil boring (WR-SB01) was drilled and sampled on July 22, 1998, between the two ramps of the wash rack. The boring was drilled to a

depth of 11.5 feet bgs using a hollow-stem auger. Three soil samples were collected from this boring using a split-spoon sampler. A boring log is presented as Figure D-19 in Appendix D.

6.9.3 Field Observations

Because of the thickness of the root mat at the surface sample locations, the surface sample depth intervals were 2 to 6 inches bgs. Screening of the soils during the collection of surface and subsurface soil samples was conducted by using a PID meter. Surface soil sample WR-SS-01-01 had a PID measurement of less than 1 ppm; the PID measurement for the WR-SS-02-01 surface soil sample was 5.2 ppm. PID measurements for the two shallower samples from boring WR-SB01 were less than 1 ppm, and the measurement for the deeper sample was 2 ppm. No sheen was noted in any of the soil samples. A petroleum-like odor was detected in soil from boring WR-SB01 between about 5 and 8 feet bgs.

About 1 inch of asphalt is present at the ground surface at location WR-SB01. About 2 feet of fill soil was encountered under the asphalt, consisting of dense, brown, slightly sandy, clayey, gravelly silt. The fill is underlain by 5 feet of stiff, brown, slightly sandy, clayey silt with organics. This unit becomes very stiff and gravelly from 5 to 7 feet, with a petroleum-like odor below a depth of 5 feet. From 7 to 11.5 feet bgs is a very stiff, mottled gray and brown, silty clay, with a petroleum-like odor from about 7 to 8 feet bgs. The soils between about 4 and 5.5 feet bgs were saturated at the time of drilling, while underlying soils were only moist, indicating the presence of perched groundwater.

6.9.4 Analytical Results

Five soil samples were collected from the Wash Rack No. 1 site. All samples were analyzed for TPH, SVOCs, and priority pollutant metals. In addition, the two subsurface soil samples were analyzed for VOCs, and the two surface soil samples were analyzed for PCBs/pesticides. The results of these analyses are summarized in Table 6-8 and described in this section.

Samples WR-SS01-01 and WR-SS02-01 were collected from surface soils. Samples WR-SB01-01, WR-SB01-02, and WR-SB01-03 were collected from depths of 2.5, 5, and 10 feet bgs, respectively. TPH, reported as unknown hydrocarbons (quantitated as diesel range), was detected in four of the five soil samples. One soil sample (WR-SS01-01) contained TPH at a concentration of 2,100 mg/kg, which exceeds the MTCA Method A cleanup level of 200 mg/kg for diesel-range TPH. A review of the chromatogram for sample WR-SS01-01 indicated that the peaks generally fall between C_{14} and C_{40}, with primary peaks occurring at C_{16}. The substance resembles a weathered oil-based product or a weathered diesel-oil mixture.

Samples WR-SB01-02 and WR-SB01-03 were analyzed for VOCs. The only VOC detected was acetone, in sample WR-SB01-02. It was detected at a concentration of 0.083 mg/kg, which is below all regulatory screening criteria. Acetone is a common laboratory contaminant.

SVOCs were detected in two of the five samples. Bis(2-ethylhexyl)phthalate was detected in sample WR-SS01-01, and di-n-butyl phthalate was detected in sample WR-SS02-01. Both SVOCs were detected at concentrations below the regulatory screening criteria, and both are common laboratory contaminants.

In the surface soil samples, no PCBs were detected, and the pesticides detected were found at concentrations below regulatory criteria. Specifically, 4,4-DDT was detected below regulatory screening criteria in both surface soil samples, and alpha chlordane and gamma chlordane were detected at concentrations below regulatory screening criteria in sample WR-SS01-01.

Antimony, nickel, selenium, silver, zinc, and mercury were detected in most or all of the samples, but at concentrations below regulatory screening criteria. Arsenic, barium, beryllium, chromium, and copper were detected in all five soil samples at concentrations exceeding one or more of the regulatory screening criteria. However, none of the detected concentrations of arsenic, barium, beryllium, or chromium exceeded the background levels. Although copper exceeded the background concentration of 114 mg/kg in one subsurface soil sample (163 mg/kg in sample WR-SB01-03), the concentration was less than two times background. Copper was also detected in the method blank associated with this sample. Cadmium was detected in one surface soil sample (WR-SS01-01) at a concentration slightly exceeding the MTCA Method B groundwater protection level and exceeding background (although less that two times background). Lead was detected in one surface soil sample at a concentration well above background. Sample WR-SS01-01 contained lead at a concentration of 766 mg/kg, which exceeds both the MTCA Method A (250 mg/kg) and the EPA Region 3 (400 mg/kg) screening levels.

6.9.5 Discussion of Results

The vehicle wash rack at the Wash Rack No. 1 site still exists. A small stream exists adjacent to the site to the east. This stream eventually discharges to Lacamas Creek. Contaminants released from aboveground vehicle maintenance or cleaning activities could either impact underlying soil or migrate via surface water runoff to the adjacent stream. Contaminants in soil may also migrate to shallow groundwater. Perched groundwater was encountered during drilling at this site within a thin zone at approximately 4 to 5.5 feet bgs.

Surface and subsurface soil samples were collected beneath the wash rack area. One surface soil sample contained TPH, cadmium, and lead at concentrations above the screening criteria (and background for the metals). The cadmium concentration in this sample did not exceed two times background. Copper was detected at a concentration above one of the screening criteria and slightly above background (but below two times background) at 10 feet bgs in one sample.

Potential exposure routes include ingestion and dermal contact with contaminated soil, groundwater, surface water, and sediments. Potential receptors for contamination detected at this site include site workers and visitors, as well as terrestrial and aquatic biota.

6.10 GREASE PITS

6.10.1 Site Characteristics

Three grease pits have been identified at Camp Bonneville: two are located in the Camp Bonneville cantonment north of Building 1828 (Figure 6-2), and one is located in the Camp Killpack cantonment east of Building 4389 (Figure 6-5). The grease pits in the Camp Killpack and Camp Bonneville cantonments have been assigned BRAC parcel numbers 11(7)HR(P) and 6(7)HR(P), respectively. Each of the grease pits consists of a gravel-filled excavation with a corrugated metal pipe extending vertically down into the gravel. The grease pits were used for disposal of waste cooking greases and oils from nearby mess halls. Use of the pits reportedly began around 1935 and continued until recently. During an interview performed as part of the EBS, the potential for the disposal of unauthorized materials in the pits was suggested.

The two grease pits in the Camp Bonneville cantonment (Figure 6-2) are located north of the mess hall and associated structures. They occupy a flat, elevated area north of the gravel road. The ground surface is covered with grass and slopes steeply down to a ditch and the gravel road, approximately 10 feet south of the grease pits. Several rows of concrete tent pads remain immediately north of the pits. Each of these grease pits consists of a single corrugated metal pipe approximately 18 inches in diameter. The pipes are approximately 1.5 feet apart. There are no lids on these grease pits, and trash was found in both.

The grease pit at the Camp Killpack cantonment (Figure 6-5) is located approximately 10 feet east of the gravel road that runs north-south, on the east side of the former mess hall building (Building 4389). Small ditches run along both sides of the gravel road. The grease pit is located just inside a heavily wooded area; access is somewhat limited by the trees. The visible portion of the grease pit consists of two corrugated metal pipes, one inside the other. The outer pipe is approximately 16 inches in diameter, and the inner pipe is approximately 10 inches in diameter. The pipes are covered with a metal lid. Photographs of the sites are provided in Appendix A.

6.10.2 Site Investigations

6.10.2.1 Camp Bonneville Grease Pits

The hollow-stem auger drill rig was used to pull out one of the corrugated metal pipes in the Camp Bonneville grease pit area. Based on the length of corrugated pipe, it was determined that the grease pit was approximately 3.5 to 4 feet deep. Two soil borings were drilled (using a hollow-stem auger) and logged adjacent to the drain rock-filled area surrounding the corrugated metal pipes. Bedrock was encountered at approximately 10 feet bgs in boring GP-SB01 and at 9 feet bgs in boring GP-SB02. Therefore, the available sampling interval was only between about 3.5 feet bgs (the approximate bottom of the grease pit) and 9.5 feet bgs (bedrock). Samples originally collected from borings GP-SB01 and GP-SB02 were improperly handled by the shipping company and had to be discarded. On August 4, 1998, soil boring GP-SB02A was advanced immediately adjacent to boring GP-SB02, using a GeoProbe™ drive sampler and a solid-stem auger. Two soil samples were collected for chemical analysis from boring GP-

SB02A from the 3.5- to 5.5- and 6- to 8-foot intervals. Logs of the borings are presented as Figures D-20 through D-22 in Appendix D.

6.10.2.2 Camp Killpack Grease Pits

On August 3, 1998, a GeoProbe™ was used to drill and sample a soil boring (GP-SB03) adjacent to the Camp Killpack grease pit. (A ditch and nearby trees prevented access by the drilling rig.) Two soil samples and a duplicate sample (GP-SB06-01) were collected, starting at the assumed depth of the bottom of the pit drain rock (based on the construction of a similar pit at the Camp Bonneville cantonment). The samples were collected from the 3- to 5- and 5- to 7-foot intervals. A third sample could not be collected because of auger refusal on cobbles. The boring log is presented as Figure D-23 in Appendix D.

6.10.3 Field Observations

6.10.3.1 Camp Bonneville Grease Pits

The removed grease pit pipe was approximately 6 feet long and had extended approximately 3.5 feet into the ground. Debris (trash, including paper and food cans) was present on the surface of the drain rock inside the grease pit pipes. An attempt was made to drill down through center of the grease pit; however, the presence of large rocks (up to about 1 foot in diameter) prevented this. Several attempts were made to drill through the drain rock. Ultimately, it was necessary to drill just outside of the edge of the rock-filled area.

PID measurements for all sample locations were less than 1 ppm, and no sheen, staining, or odor were noted during drilling and sampling at the Camp Bonneville grease pits. Soils encountered in boring GP-SB01 consisted of 5 feet of soft, brown, slightly sandy, clayey silt, underlain by 5 feet of dense, brown, slightly sandy, clayey, gravelly silt with scattered organics. Volcanic rock was encountered from 10 to 12.5 feet (bottom of boring). Soils encountered in borings GP-SB02 and GP-SB02A consisted of 3.5 to 4.5 feet of soft, brown, slightly sandy, gravelly, clayey silt with scattered organics, underlain to a depth of 5.5 feet by medium dense, brown and gray, silty, gravelly sand. Between 5.5 and 8 feet bgs, the sand became very dense and slightly clayey. From 8 to 9 feet, the soil was dense, brown and gray, slightly clayey to clayey, sandy, silty gravel. Bedrock was encountered at 9 feet bgs.

Groundwater was not encountered in the subsurface soils. However, occasional wet seams were present between 5 and 10 feet deep in GP-SB01, and iron staining (indicative of wet season water levels) was observed below about 3.5 feet at GP-SB02 and GP-SB02A.

6.10.3.2 Camp Killpack Grease Pit

The explorations adjacent to the Camp Killpack grease pit encountered brown, silty to slightly silty sand with scattered cobbles. Occasional creosote-treated wood fibers were found below 5 feet bgs. The explorations could not be advanced below a depth of 7 feet because of the presence of cobbles. No staining, odors, sheen, or PID readings above 0 ppm were noted during drilling and sampling. No groundwater was encountered.

6.10.4 Analytical Results

Four soil samples and one duplicate/split sample were collected from the two grease pits. All samples were analyzed for TPH, SVOCs, PCBs/pesticides, VOCs, and priority pollutant metals. The results of these analyses are summarized in Table 6-9 and described in this section.

TPH was not detected in any sample, with the exception of sample GP-SB03-01. Unknown hydrocarbons were detected in sample GP-SB03-01 at a concentration of 82 mg/kg (quantitated as diesel range), which is below the MTCA Method A cleanup level. The laboratory noted that the chromatographic profile was not consistent with reference field standards. One SVOC was detected at estimated concentrations in two samples. Diethyl phthalate was detected in samples GP-SB02-01 and GP-SB03-02, at concentrations below regulatory screening criteria; diethyl phthalate is a common laboratory contaminant. VOCs and PCBs were not detected in any of the samples. No pesticides were detected in any of the samples with the exception of sample GP-SB02-02, in which gamma-BHC (lindane) was detected at concentrations of 2.0 mg/kg and 3.6 mg/kg for first and second column confirmation, respectively. These concentrations are below the regulatory screening criteria.

Arsenic, beryllium, chromium, and copper were detected in most or all five samples at concentrations exceeding one or more of the regulatory screening criteria. However, the detected concentrations of chromium and beryllium did not exceed background levels. Additionally, the chromium data were qualified because of method blank contamination. Arsenic slightly exceeded the background level of 7 mg/kg only in sample GP-SB03-02 (7.9 mg/kg). This arsenic concentration exceeded the MTCA Method B and EPA Region 3 screening criteria. Copper slightly exceeded the background concentration of 114 mg/kg in sample GP-SB02-01 (133 mg/kg). This copper concentration exceeded the MTCA Method B groundwater protection criterion. Thallium and barium were detected in three samples in excess of the MTCA Method B groundwater protection level; however, only sample GP-SB03-01 had a thallium concentration above the background level (but less than two times background). Barium exceeded the background level of 257 mg/kg in both samples collected from boring GP-SB02 (369 and 374 mg/kg). Antimony, cadmium, lead, nickel, selenium, silver, and zinc were detected in most or all of the samples, but at concentrations below the regulatory criteria.

6.10.5 Discussion of Results

The three grease pits were constructed of perforated metal pipes extending vertically into large drain rock. Based on the pipe length observed in one of the pits, they extended to a depth of approximately 4 feet bgs. Contaminants released from the grease pits would enter subsurface soil. Contaminants in soil could migrate to groundwater. Groundwater was not encountered during sampling at the grease pit sites.

Four subsurface soil samples were collected from locations immediately adjacent to the grease pits, at depths corresponding to the apparent sides and bottoms of the pits. Although several metals were detected in one sample each at a concentration exceeding both background and one

or more of the screening levels, none of these concentrations exceeded two times background. Only barium exceeded the background level, as well as the regulatory criterion for groundwater protection, in more than one soil sample (in the Camp Bonneville cantonment area).

6.11 PESTICIDE MIXING/STORAGE BUILDING

6.11.1 Site Characteristics

The Pesticide Mixing/Storage Building, Building 1864, is located in the Camp Bonneville cantonment (Figure 6-2). It is a wood-frame building with a concrete slab-on-grade floor. The structure was reportedly built in 1955, and was earlier used as the Camp Bonneville Fire Station. According to the EBS, the building was used for pesticide mixing and storage from 1977 until 1980. During that time, the building reportedly was used for storing 55-gallon drums of 2,4,5-T; 2,4-D; and DDT. More recently, the building has been used as the grounds shop for storage of equipment, vehicles, small gasoline containers, and car batteries. This site has been assigned BRAC parcel number 9(7)HR(P).

The Pesticide Mixing/Storage Building is located approximately 70 feet north of the main access road. The surrounding area is covered with grass and slopes downward to the south-southeast. Two other buildings exist to the north and northeast of the site. The remainder of the Camp Bonneville cantonment is located to the east of the site. A small creek, located roughly 130 feet east of the Pesticide Mixing/Storage Building, flows southward to Lacamas Creek.

A sink in the building was recently discovered to discharge into a dry well located along the eastern exterior wall of the building. This sink reportedly was used during pesticide mixing and pesticide container and applicator cleaning. According to the former Camp Bonneville Facility Manager, the dry well was identified when an attempt was made to improve drainage of the sink. The sink drain pipe extends out from the base of the building, into a 90° coupling, and then enters the ground. The pipe area was excavated and found to be surrounded by large drain rock to a depth of about 3 feet. The drain pipe empties into the drain rock. Photographs of the site are provided in Appendix A.

6.11.2 Site Investigation

Surface soil samples were collected from two locations (PM-SS01 and PM-SS02) in front of (south of) the Pesticide Mixing/Storage Building. These samples were collected from depths of approximately 0 to 6 inches bgs in the vicinity of the garage doors that provide vehicular/equipment access to the building. These surface soil sampling locations were added to the sampling program following submittal of the Management Plan, based on discussions with the Corps regarding reports of possible pesticide spillage in front of the building.

Four soil borings were advanced in three areas at the site between July 21 and 22, 1998. The direction of groundwater flow was assumed to be to the south-southeast, based on topography.

Two borings were drilled in the assumed upgradient location (PM-SB01 to 40 feet, and adjacent PM-SB01A to 29 feet). Boring PM-SB01A was used for installation of the upgradient monitoring well (PM-MW01), while boring PM-SB01 was used to collect subsurface soil samples. Boring PM-SB02 was used for soil sampling and installing the downgradient monitoring well (PM-MW02). These borings were drilled using a hollow-stem auger drill rig. Boring PM-SB03 was drilled adjacent to the dry well, using a hand auger, because overhead power lines were present. Soil samples for chemical analysis were collected from three intervals in each of borings PM-SB01, PM-SB02, and PM-SB03. Duplicate and split samples were collected with sample PM-SB03-02. MS/MSD samples were collected with sample PM-SB03-03. The wells were installed to depths of 27.2 feet bgs (PM-MW01) and 20.1 feet bgs (PM-MW02) on July 22, 1998. Logs of the borings are presented as Figures D-24 through D-26 in Appendix D.

The groundwater monitoring wells were developed on July 28 and 29, 1998, using a Teflon™ bailer. The wells were actively developed for about four hours each, over a period of 1½ days (because recovery was slow). During development, approximately 15.5 and 18.5 gallons of water were extracted from PM-MW01 and PM-MW02, respectively. The wells were purged and sampled for chemical analysis on August 5, 1998.

6.11.3 Field Observations

6.11.3.1 Soil

Surface soils encountered on the south side of the building consisted of dense, brown, silty, sandy gravel with common grass roots (fill). The surface soil sampling logs are presented in Appendix C. Fill soils were also encountered to a depth of about 3 feet in the hand auger boring adjacent to the dry well on the east side of the building. These soils consisted of brown, slightly sandy, gravelly, clayey silt with cobbles.

Subsurface soils encountered in the upgradient and downgradient borings and below the fill at the dry well include a considerable thickness of hard brown to mottled gray and brown, slightly clayey to clayey silt with minor sand and occasional organics. The soil consistency decreases to medium stiff below the water table (about 15 feet bgs at PM-SB01 and about 10 feet bgs at PM-SB02), and the sand and gravel content of the soil increases below this point. At the base of the saturated zone, the soils grade to medium dense, gray, sandy, gravelly silt (24.5 to 28 feet deep in PM-SB01) to dense, silty, sandy gravel (17 to 19 feet in PM-SB02). Below the saturated zone is hard, gray, silty clay with scattered organics (from 28 to 37 feet deep at PM-SB01, and from 19 to at least 21.5 feet deep at PM-SB02). Moderately hard, weathered, volcanic rock was encountered below 37 feet at PM-SB01. Logs of the borings are presented as Figures D-24 through D-26 in Appendix D.

PID readings for the retrieved soil samples were 0 to 1 ppm for the surface and subsurface soils. No soil sheen, staining, or unusual odors were observed during sampling.

6.11.3.2 Groundwater

The water table beneath the site ranges from approximately 15 feet bgs in the upgradient well to about 10 feet bgs in the downgradient well. The saturated zone was less than 10 feet thick at the time of sampling. This perched aquifer has a low yield, primarily from the granular soils. Soils were moist or moist to wet in the fine-grained soils above the water table, saturated in the granular soils below the water table, and moist in the fine-grained soils and underlying rock. Groundwater parameters measured at the time of sampling are presented in Table 6-1.

No sheen, odors, or elevated PID readings were noted during well development and sampling, with one exception. The initial PID reading was 2 ppm in the PM-MW02 well casing at the start of development. The PID reading immediately dropped to 0 ppm and remained at 0 ppm during development and later sampling. The initial PID reading may have been elevated in response to the initial humidity level inside the well.

Because of the slow recovery of well PM-MW01, samples from this well were collected over a 5-hour period. Well PM-MW02 recovered more rapidly, with samples being collected over a 45-minute period.

Groundwater levels were measured in the wells on August 3, 1998 (Table 4-4), and again during groundwater sampling on August 5, 1998. The groundwater levels measured at the time of sampling were about 2 feet higher than those measured during drilling; this is common for wells installed in fine-grained soils. The groundwater elevation decreases by nearly 4 feet from the upgradient well to the downgradient well, supporting the assumption that groundwater flow is generally southward. An additional crossgradient well would be required in this area in order to determine more precisely the magnitude and direction of the groundwater gradient. Iron staining and mottling observed in soil samples collected from 8.5 to 14.5 feet at PM-SB01 and from 7 to 9.5 feet at PM-SB02 are likely indicative of the typical wet season water table level.

Another round of water level measurements was made in the wells on December 16, 1998. The water levels measured on that date had increased 2.34 feet (in well PM-MW01) and 2.07 feet (in well PM-MW02) from the August 3, 1998 levels (see Table 6-1). This indicates a greater hydraulic gradient between the two wells than was determined based on the August 1998 measurements.

6.11.4 Analytical Results

Two surface soil samples, nine subsurface soil samples (and one duplicate/split sample), and two groundwater samples were collected at the Pesticide Mixing/Storage Building site. Samples were analyzed for TPH, VOCs (only on subsurface samples), SVOCs, PCBs/pesticides, organophosphorus pesticides, chlorinated herbicides, and priority pollutants metals. The results of these analyses are summarized in Tables 6-10 and 6-11. Sample locations are shown in Figure 6-2.

6.11.4.1 Surface Soil Samples

Unknown hydrocarbons (quantitated as diesel range) were detected in both surface soil samples collected in front of the building at concentrations just above and below the MTCA Method A cleanup level of 200 mg/kg. A review of the sample chromatograms indicated that the petroleum hydrocarbons eluted in the diesel range and slightly heavier; the substance may be a weathered diesel or diesel-oil mixture. Three SVOCs were detected in the surface soil samples. Bis (2-ethylhexyl)phthalate and di-n-butyl phthalate were detected in one or both samples at trace levels and below the screening levels. Hexachlorobenzene was detected in one sample (PM-SS02-01) at 0.19 mg/kg, which is above the MTCA Method B groundwater protection criterion. The pesticide compounds 4,4-DDE, 4,4-DDD, and 4,4-DDT were detected in both surface soil samples. The concentrations of 4,4-DDE and 4,4-DDT in sample PM-SS02-01 exceeded the MTCA Method B groundwater protection criteria. The chlorinated herbicides 2,4,5-T and 2,4-D were also detected: 2,4,5-T at estimated concentrations in both surface soil samples, and 2,4-D in sample PM-SS01-01 only. No screening criteria are available for either compound. Organophosphorus pesticides and VOCs were not detected in either sample.

Arsenic, barium, beryllium, cadmium, chromium, copper, and lead were detected in one or both surface soil samples at concentrations exceeding one or more of the regulatory criteria. However, only arsenic, cadmium, and lead were detected at concentrations exceeding background levels. Arsenic was detected in one sample (PM-SS02-01) at a concentration above the MTCA Method B and EPA Region 3 screening criteria and above background (but not greater than two times background). Cadmium was detected in both surface soil samples at concentrations equal to or exceeding the MTCA Method A and Method B groundwater protection criteria, and above background. Lead concentrations in the two surface soil samples were well above background, with sample PM-SS02-01 exceeding the MTCA Method A criterion.

6.11.4.2 Soil Boring Samples

PCBs/pesticides, organophosphorous compounds, and chlorinated herbicides were not detected in the soil boring samples. Low concentrations of unknown hydrocarbons were detected in six of the soil boring samples (below the screening criteria). Acetone was detected in two of the samples at concentrations below regulatory levels, and carbon disulfide was detected in one sample at a concentration below regulatory levels. One SVOC, butyl benzyl phthalate, was detected in one sample at an estimated concentration below regulatory criteria.

Arsenic, barium, beryllium, cadmium, chromium, copper, and thallium were detected in soil boring samples at concentrations above one or more of the regulatory levels. However, of these metals only copper and cadmium were detected at concentrations that exceeded the background levels. Copper was detected at elevated concentrations (exceeding MTCA Method B groundwater protection criteria and background) in two samples from the upgradient boring (PM-SB01-02 and PM-SB01-03) and one sample from the downgradient boring (PM-SB02-03). Cadmium was detected in one sample (PM-SB03-02) at a concentration above the MTCA Method A and Method B groundwater protection criteria and above the background level, although the concentration of cadmium in a duplicate sample was beneath all of the regulatory

and risk-based screening criteria. The remaining metals were not detected at concentrations above the screening criteria.

6.11.4.3 Groundwater

No TPH, VOCs, SVOCs, PCBs/pesticides, organophosphorous pesticides, or chlorinated herbicides were detected in the groundwater samples. Dissolved arsenic was detected in the downgradient well (PM-MW02-01) at a concentration exceeding the MTCA B and EPA Region 3 criteria; however, it did not exceed the MCL. Arsenic was not detected in the unfiltered sample from this well or in samples (filtered and unfiltered) collected from the upgradient well. Water quality parameters were all below regulatory criteria where detected.

6.11.5 Discussion of Results

Two potential source areas of concern were identified at the Pesticide Mixing/Storage Building site; a pesticide-handling area in front of the building and a shallow dry well (approximately 3 feet deep) on the east side of the building. Contaminant migration via soil is expected to be the primary release mechanism at the site. Contaminants in surface soil may also migrate via surface water runoff, while contaminants in subsurface soil may migrate to groundwater. Perched groundwater was encountered at depths of 10 to 15 feet bgs at the site. Groundwater appears to flow generally to the south, and is assumed to flow toward and discharge to Lacamas Creek, located roughly 800 feet to the south.

Soil samples were collected from the dry well area (subsurface samples), in front of the building (surface samples), and in upgradient and downgradient locations used for monitoring well installation. TPH, pesticides, cadmium, and lead were detected at concentrations exceeding one or more of the screening criteria (and background, where applicable) in surface soil samples from in front of the building. Possibly elevated concentrations of copper and cadmium (exceeding the MTCA Method B groundwater protection criteria and background, but not risk-based criteria) were detected in deeper soil samples.

Groundwater samples were collected from one upgradient and one downgradient well at the site. No constituents were detected at concentrations of concern (exceeding the screening criteria) in the unfiltered groundwater samples. Although arsenic was detected in the filtered sample (dissolved arsenic) from the downgradient well, it was not detected in the corresponding non-filtered sample (total arsenic).

Potential exposure routes include ingestion and dermal contact with contaminated surface soil. Potential receptors for contaminants detected in surface soil at the site include site workers and future site visitors, as well as terrestrial biota.

6.12 ABOVEGROUND STORAGE TANKS

6.12.1 Site Characteristics

There are 26 ASTs at Camp Bonneville; 3 are located in the Camp Killpack cantonment (Figure 6-2), and 23 are located in the Camp Bonneville cantonment (Figure 6-5). The ASTs are Category 2 parcels and have been assigned BRAC parcel number 7(2)PS. The 275-gallon ASTs, which are located adjacent to the exteriors of buildings, are used to store fuel oil (diesel fuel) for furnaces that heat the buildings. According to the EBS, ASTs have been used for fuel oil storage in the Camp Bonneville cantonment since the late 1920s or early 1930s, and in the Camp Killpack cantonment since about 1935. Three of the tanks reportedly are still in use: those at the shop office building, the fire station, and the laundry, all within the Camp Killpack cantonment. During performance of the EBS, no documentation was found of releases from the tanks; however, incidental spillage was reported to have occurred during tank filling. No evidence of petroleum was observed on the ground around the tanks at that time. Photographs of representative ASTs are provided in Appendix A.

6.12.2 Site Investigation

Each of the AST locations was inspected for evidence of leaks or spills. The scope of work was based on the assumption that evidence of contamination would be found at a total of three AST locations. However, stained soil, odors, and/or elevated PID readings were observed in soil under eight ASTs. As directed by the Corps, samples were collected from all locations exhibiting evidence of contamination, no matter how small the affected area appeared to be. Therefore, surface soil samples were collected from eight AST locations, all within the Camp Bonneville cantonment area (Figure 6-2). The samples were collected from the visibly contaminated soil, typically only a few inches deep, and no more than 6 inches bgs. A duplicate sample was collected from location ST-SS-05.

6.12.3 Field Observations

Stained soil and sheens were observed at all eight sampling locations. PID readings for the samples ranged from 1 to 19 ppm. At the time of sampling, ponded water was present under several of the ASTs, making an estimate of the extent of contaminated soils more difficult. In general, however, visual evidence indicated that the contamination at these sites was limited to a very small area and a shallow depth (on the order of several inches). Even where darkly stained soil or free product was present at the surface, removal of the upper few inches of soil typically exposed unstained and odor-free soil. The area of contaminated soil typically appeared to be limited to the area immediately under the tanks.

6.12.4 Analytical Results

The results of the AST analyses are summarized in Table 6-12. Eight soil samples and one duplicate sample were collected from soils below ASTs located in the Camp Bonneville

cantonment. All samples were analyzed for TPH using Washington State methods WTPH-HCID and WTPH-D. All eight samples had TPH results well above the MTCA Method A criterion of 200 mg/kg for diesel-range hydrocarbons. Five soil samples and the duplicate sample (ST-SS04-01, ST-SS05-01, ST-SS05-02, ST-SS06-01, ST-SS07-01, and ST-SS08-01) contained TPH, reported as diesel fuel No. 2, at concentrations above 200 mg/kg. Three of the eight samples (ST-SS01-01, ST-SS02-01, and ST-SS03-01) had concentrations of unknown hydrocarbons (quantitated as diesel range) above 200 mg/kg. A review of the chromatograms for these three samples indicated that the peaks generally fell within the diesel range, with some peaks extending up to C_{26}. Based on site usage and the chromatograms, the substance appears to be weathered to highly weathered diesel.

6.12.5 Discussion of Results

Of the existing 26 ASTs at the facility, 3 are located in the Camp Killpack cantonment and 23 are located in the Camp Bonneville cantonment. Petroleum constituents released from the ASTs may enter underlying soil or migrate via surface water runoff. Contaminated surface runoff may flow to nearby creeks. Surface soil samples were collected from all locations where field evidence (including staining, odor, and elevated PID readings) of soil contamination was observed. Concentrations of TPH (diesel range) exceeding the MTCA Method A criterion were detected in soil from all eight locations sampled (all within the Camp Bonneville cantonment).

The small creeks in the Camp Bonneville cantonment area all appear to ultimately drain into Lacamas Creek (at a distance of 500 feet or more). Field evidence of contamination (staining and odor) indicated that elevated concentrations of petroleum did not penetrate far into underlying soil; therefore, groundwater is not considered a significant potential pathway for this surface contamination.

Potential exposure routes include ingestion and dermal contact with contaminated surface soil, surface water, and sediments. Potential receptors include site workers and site visitors, as well as terrestrial and aquatic biota.

6.13 FORMER SEWAGE POND

6.13.1 Site Characteristics

The Former Sewage Pond site, BRAC parcel number 17(7)HR(P), is located south of the Camp Bonneville cantonment area (Figure 6-6). The exact location and dimensions of the pond were not documented. According to the former Facility Manager, the pond was an unlined lagoon that was pumped out and filled with clean dirt derived from a local source when it was abandoned. It reportedly was used for sewage disposal until 1978, when the existing sewage lagoon was constructed. The years of pond usage are not known; however, according to the current Facility Manager, it may have been used for only a short period of time. Although there are no records of hazardous materials disposal in the sewage pond and no evidence of contamination has been

observed in the area, the potential for contamination could not be discounted given the nature and purpose of the facility. There was also a potential for UXO at the site because of munitions misfires impacting outside of established range fans, unauthorized munitions disposal, or other activities. The general site area is on the floodplain of Lacamas Creek, and the terrain is low-lying and flat. Water tends to pond in much of this area during the wet season. Lacamas Creek is approximately 200 feet southeast of the site at the closest point. Photographs of the site are presented in Appendix A.

6.13.2 Site Investigations

A UXO avoidance/screening survey was performed in the Former Sewage Pond area on July 8, 1998, by two UXO specialists. Magnetic anomalies were flagged and avoided during subsequent activities at the site. A large area (including access to the site) was initially surveyed. The UXO specialists surveyed additional areas, as needed, as the field work progressed.

An EM survey was performed in the suspected pond area on July 9 and 10, 1998. GPR equipment was not used because of the high natural ground conductivity and uneven terrain at the site. A report describing the procedures and findings of the geophysical investigation is presented in Appendix B.

Soil borings were drilled at five locations in the Former Sewage Pond area between July 17 and 20, 1998. The borings were drilled to characterize subsurface conditions and to collect samples for chemical analyses. Three of these borings (SP-SB01, SP-SB02/2A, and SP-SB03/3A) were drilled within the apparent former pond area. Using a hand auger, UXO personnel advanced borings SP-SB01, SP-SB02, and SP-SB03 to depths of at least 6 feet bgs. The hollow-stem auger drill rig was then used to complete the drilling and sampling of SP-SB01, SP-SB02A (drilled adjacent to SP-SB02), and SP-SB03. After completion of hollow-stem auger drilling at SP-SB03, a 4.5-foot-deep hand auger hole (designated SP-SB03A) was drilled adjacent to SP-SB03 to collect a sample at the apparent pond bottom depth, along with duplicate and split samples.

The two other soil borings (SP-SB04 and SP-SB05) were drilled to collect soil samples for chemical analysis and for the installation of monitoring wells. The direction of groundwater flow was assumed to be to the south-southeast, based on site topography and the proximal position of Lacamas Creek. One well was installed in a location assumed to be downgradient of the Former Sewage Pond (SP-SB04/SP-MW01). The other well (SP-SB05/SP-MW02) was installed in an assumed upgradient location. Using a hand auger, UXO personnel advanced each of these borings to a depth of 5 feet bgs. The hollow-stem auger drilling rig was then used to complete the borings and well installations.

Three samples were collected from each boring. The uppermost sample was collected from the apparent pond bottom depth or the approximate water table interface (whichever came first), as noted during hand augering. Because of the shallow water table and the safety requirement for initial advancement of the holes by the UXO specialists using a hand auger, the upper one or two

soil samples for chemical analysis at each boring were collected from the hand auger barrel. The remaining samples were collected by using a split-spoon sampler. Logs of the borings are presented as Figures D-27 through D-32 in Appendix D.

The groundwater monitoring wells at the Former Sewage Pond site were installed on July 20 and 21, 1998, and developed on July 28, 1998. The wells were developed for about four hours each, the maximum time specified in the plan. Approximately 40 gallons of development water were removed from SP-MW01 and 31 gallons were removed from SP-MW02. The wells were purged and sampled on August 5 and 6, 1998. Groundwater field parameters were monitored and recorded during well sampling. These parameters are summarized in Table 6-1.

6.13.3 Field Observations

During the UXO survey, a roughly circular area of magnetic anomalies was detected. Several fence posts were identified in this area of anomalies, lying horizontally, just under the ground surface. The roughly circular pattern of anomalies also roughly coincided with a slight elevation rise near the center of the old parade grounds. Although the initial UXO survey activities were directed in the southeastern portion of the old parade grounds, after finding these features, efforts were concentrated in the slightly mounded area.

The current Facility Manager said he had been told that the pond was filled to form a slight rise, although he was not aware that it had been fenced. The location of the anomalous area detected by the UXO magnetometers agreed with the location previously related to the Facility Manager. Results of the EM survey were inconclusive at this site.

6.13.3.1 Soil

The pond area borings were drilled into volcanic rock, at depths of up to 21.5 feet bgs. Soil samples were collected from each (assumed) pond interior boring at the apparent pond bottom (approximately ¼-inch-thick horizon of dark soil) at approximately 4 to 5 feet bgs. Two additional samples were collected at each location at greater depths. No sheen, odor, or elevated PID readings were observed during field screening of soil samples from the borings.

Fill soils were encountered in the borings drilled within the assumed footprint of the Former Sewage Pond. Fill at borings SP-SB01 through SP-SB03A consists of 4.5 to 5 feet of brown, slightly sandy, clayey silt. A thin, dark layer of soil was generally identified near the base of the fill; this layer was interpreted as the former pond bottom. The soils present between 0 and 5 feet bgs in the upgradient and downgradient borings (SP-SB04 and SP-SB05) consisted of brown, clayey silt with minor sand and gravel. Iron staining and/or mottling was typically observed in shallow soils (both fill and native).

The native soils encountered below the fill at the assumed pond site, and below 5 feet at the other locations, consist of about 4 to 9.5 feet of very stiff to hard or medium dense to very dense, mottled brown and gray, sandy, clayey silt, with scattered organics. This unit is commonly iron-stained. This silt grades downward into a medium dense to very dense, silty, sandy

gravel/gravelly sand, generally between 3 and 6 feet thick, encountered at depths of approximately 9 to 15 feet bgs. This gravelly unit is underlain by highly weathered volcanic rock.

6.13.3.2 Groundwater

Groundwater was encountered at depths of about 4 to 5.5 feet in most of the Former Sewage Pond borings. The silt below this depth was moist, with scattered wet zones at some locations. The sand/gravel unit was saturated, and the underlying rock was moist. Groundwater levels were measured in the wells on August 3, 1998 (Table 4-4), and again during groundwater sampling on August 5 and 6, 1998. These groundwater levels were similar to those measured during drilling. No sheen, odor, or PID readings above 1 ppm were noted in groundwater during well development or sampling.

The groundwater elevation decreases by nearly 3 feet from the upgradient well to the downgradient well, supporting the previous assumption that groundwater flow is generally to the south or southeast, toward Lacamas Creek. As with the nearby Landfill 2 and Landfill 3 sites, the groundwater flow direction is probably influenced by Lacamas Creek. At least one additional crossgradient well would be required at the Former Sewage Pond site in order to determine more precisely the magnitude and direction of the groundwater gradient. The iron staining and mottling observed in shallow soil samples indicate that the typical wet season water table is probably within a foot of the ground surface over most of the site. Consequently, the lagoon would have been in direct contact with the water table for much, if not all, of the year.

Another round of water level measurements was made in the wells on December 16, 1998. The water levels in the upgradient well and downgradient well were 2.61 feet and 2.29 feet higher, respectively, than when measured on August 3, 1998 (see Table 6-1). This indicates an even greater hydraulic gradient between the two wells than during the summer.

6.13.4 Analytical Results

6.13.4.1 Subsurface Soil Samples

Fifteen soil samples and two duplicate/split samples were collected at the site. All samples were analyzed for TPH, SVOCs, VOCs, PCBs/pesticides, and priority pollutant metals. The results of these analyses are summarized in Table 6-13 and discussed in this section.

No TPH, SVOCs, PCBs, or pesticides were detected in the Former Sewage Pond samples. The only two VOCs detected were at concentrations below the screening criteria. Specifically, sample SP-SB03-03 contained acetone at 0.0037 mg/kg, and sample SP-SB05-03 contained carbon disulfide at 0.0052 mg/kg. Both are common laboratory contaminants.

Arsenic, beryllium, chromium, copper, and thallium were detected at concentrations above one or more of the regulatory screening criteria. However, only arsenic, copper, and thallium were detected at a concentration that exceeded the background level. Arsenic was detected in all samples; however, only one sample (SP-SB03-02) contained arsenic at an elevated

concentration (above the screening levels and background). Copper also was detected in all soil samples, with only one sample (SP-SB05-03) exceeding the MTCA Method B groundwater protection criteria and background. Thallium was detected in five samples, with four samples containing thallium at estimated concentrations above the MTCA Method B groundwater protection level, one of which (SP-SB03-03) also exceeded the background concentration (but not two times background).

Antimony, cadmium, lead, nickel, silver, and zinc were detected in all samples at concentrations below regulatory screening levels. Mercury was detected in two samples at concentrations below regulatory screening levels; and selenium was detected in one sample at a concentration below the regulatory screening level.

6.13.4.2 Groundwater

Groundwater samples collected from the two monitoring wells at the Former Sewage Pond site were analyzed for TPH, VOCs, SVOCs, priority pollutant metals (total and dissolved), water quality parameters, fecal coliform, and fecal strep. The results of these analyses are summarized in Table 6-11 and discussed below. Results of groundwater field measurements are summarized in Table 6-1.

No TPH, VOCs, or SVOCs were detected in any of the groundwater samples. Both total and dissolved arsenic were detected in the upgradient well sample (SP-MW02-01) at concentrations exceeding the MTCA Method A and B, and EPA Region 3, regulatory screening levels, but below the MCL. Arsenic was not detected in the downgradient well. Barium, chromium, copper, nickel, selenium, and zinc were detected in both monitoring wells, at concentrations below regulatory screening criteria. Lead also was detected in sample SP-MW02-01 at a concentration below the regulatory screening criteria.

Water quality results were very similar in both the upgradient and downgradient wells. Chloride, fluoride, sulfate, calcium, iron, magnesium, manganese, potassium, and sodium were detected in both wells at concentrations below regulatory screening criteria (where applicable). Alkalinity was detected at 112 mg/L in the sample from well SP-MW01 and 94.3 mg/L in the sample from well SP-MW02. Cyanide, nitrates, and orthophosphates were not detected in either well. Fecal coliform was detected in samples SP-MW01-01 and SP-MW02-01 at concentrations of 2 mg/L and 8 mg/L, respectively. Fecal strep was only detected in sample SP-MW02-01 (from the upgradient well) at 4 mg/L. Fecal coliform and fecal strep are not regulated by MTCA or CERCLA standards.

6.13.5 Discussion of Results

The apparent Former Sewage Pond area was determined using field evidence of soil disturbance (mounded soil) and the presence of a roughly circular outline of buried fence posts. The apparent depth of the pond bottom was approximately 4 to 5 feet bgs, based on the presence of a thin horizon of dark soil encountered. Groundwater was encountered at depths of 4 to 4.5 feet bgs in the Former Sewage Pond area during the field investigation (in the dry season), and was

measured more than two feet higher in two on-site monitoring wells during the rainy season. Therefore, it appears that the Former Sewage Pond was in contact with groundwater, at least seasonally. Groundwater at the site appears to be perched over highly weathered volcanic rock. Groundwater is assumed to flow generally to the south, toward Lacamas Creek, located approximately 200 feet from the site.

Assuming that the Former Sewage Pond partially intersected the water table, contaminants from the pond could migrate into subsurface soil or discharge directly to groundwater. Both soil and groundwater samples were collected from the site for analysis. The only constituents detected in subsurface soil samples at concentrations exceeding one or more of the regulatory/risk-based screening criteria were arsenic, copper, and thallium. Each of these metals was detected at a concentration slightly above background (but less than two times background) in only one soil sample each. Groundwater samples were collected from one upgradient and one downgradient well at the site. Arsenic was the only constituent detected in groundwater at a concentration exceeding the screening criteria; however, this was detected only in the sample from the upgradient well. No evidence of site-related contamination was detected. Slightly elevated concentrations of metals detected may be related to natural variability in background concentrations.

6.14 AMMUNITION STORAGE MAGAZINES

6.14.1 Site Characteristics

The Ammunition Storage Magazines are located east of the Camp Bonneville cantonment and southwest of the existing sewage treatment lagoon (Figure 6-7). The three magazines are designated as Buildings 2950, 2951, and 2953. These small structures are constructed of concrete with heavy metal doors, and each is covered with a mound of soil. According to the Camp Bonneville EBS, the Ammunition Storage Magazines were built in 1976. The magazines were used to store munitions of various types that were brought to Camp Bonneville for training purposes. There is no record of munitions mishaps at any of these structures.

The westernmost ammunition storage magazine, Building 2953, is the largest, with an interior floor space measuring roughly 10 feet by 10 feet. The entrance to this structure faces southward. The center magazine, Building 2951, is the smallest, with an interior floor space measuring only about 2 feet by 2 feet, and a door also facing southward. The interior floor space of the easternmost magazine, Building 2950, measures roughly 4 feet by 4 feet. The entrance to this medium-sized structure faces southeastward. The largest storage magazine is surrounded by a chain-link fence, topped with barbed wire, and with a gate northwest of the magazine. The two smaller magazines are fenced separately from the larger magazine (with one common fence side). The entrance to the larger fenced area is north of the two structures.

The area between and surrounding the ammunition storage magazines is covered with grass and low shrubs. The area is relatively flat, with a slight slope downward to the south, toward

Lacamas Creek. The creek is located immediately south of the fenced area. Photographs of the site are provided in Appendix A.

6.14.2 Site Investigations

Surface soil samples were collected from 15 locations during March 1998 (Figure 6-7). Nine sampling locations were selected in front of the largest magazine, and three in front of each of the smaller magazines. One sample was collected from each location, from a depth of 0 to 6 inches. Duplicate/split and MS/MSD samples were collected from location AS-SS-01, and an additional duplicate sample was collected from location AS-SS-08.

Instead of sampling directly in front of the largest storage magazine, the sample grid was started approximately 8 feet away from the door. This was done because of concerns regarding possible spillage of smokeless powder and/or black powder on the soil in front of the door. Sampling personnel were told by the Corps representative to assume that surface soil directly in front of the magazine was contaminated with smokeless powder and/or black powder, and not to collect a sample there.

Wipe samples were collected from the concrete floors of the three magazines, following the procedures described in Section 4.2.4. Before collecting the wipe samples, soil covering the floors of the two small magazines was swept to the side, using a new whisk broom. A sample of the soil from each magazine was collected for possible analysis. Sample AS-MG01-01 was collected from the soil inside the small magazine, Building 2951. Sample AS-MG02-01 was collected from the soil inside the mid-sized magazine, Building 2950. Following authorization by the Corps, these samples were submitted for analysis of the same parameters as the wipe samples. A duplicate wipe sample was collected inside Building 2950.

Wipe samples and interior soil samples were collected from the two smaller magazines during March 1998. Sampling inside of the larger magazine was delayed until August 1998, after materials stored in the building were removed. The floor of the larger magazine was cleaned to remove spilled smokeless powder and/or black powder before the wipe sample was collected.

One soil boring (AS-SB01) was drilled in the Ammunition Storage Magazine area using a hollow-stem auger. Laboratory samples initially collected from this boring were mishandled by the shipper, and were discarded. A second soil boring (AS-SB01A) was drilled and sampled adjacent to boring AS-SB01, using a GeoProbe™. The borings were drilled in the location of surface soil sample AS-SS10-01, which had the highest metals concentrations detected in surface soil at the site. Two subsurface soil samples were collected from the boring at depths of 2.5 and 6 feet bgs. Logs for soil borings AS-SB-01 and AS-SB01A are presented as Figures D-33 and D-34 in Appendix D.

6.14.3 Field Observations

At the time of sampling, the floors of the two smaller magazines were covered with wooden pallets and thick layers (up to about ½ inch) of wet soil. The pallets were removed, and although the soil was swept to the side before collection of the wipe samples, a thin layer of mud remained.

No odor, staining, or elevated PID readings were identified during surface soil sampling or borehole drilling. Surface soil (from 0 to 6 inches bgs) typically consists of brown, silty, sandy gravel fill. In boring AS-SB01 this fill soil is underlain by 4 feet of hard, moist, brown, slightly sandy, clayey silt, with occasional organics. From 4.5 to 7 feet bgs, the soil is dense, brown, slightly sandy, slightly clayey silt, with a trace of fine to coarse gravel. From 7 feet bgs to the bottom of the boring at 11.5 feet bgs, weathered volcanic rock was encountered. The soil from 4.5 to 7 feet bgs was moist with evidence of iron staining. Weathered rock was encountered at 6 feet bgs in boring AS-SB01A.

6.14.4 Analytical Results

Seventeen surface soil samples (including two duplicates), two subsurface soil samples, two soil samples from inside the magazines, and four wipe samples (including one duplicate) were collected from the Ammunition Storage Magazine site. All samples were analyzed for priority pollutant metals, nitroaromatic and nitramine explosives, PETN, and PA. A summary of the results is provided in Table 6-14 and described in this section.

Analytes detected in one or more of the wipe samples include RDX, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, nickel, silver, zinc, and mercury. These same constituents were detected in soil samples collected from the floors of the magazines, typically at concentrations that exceed the MTCA and/or Region 3 criteria, with the exception of nickel, silver, and zinc. Explosives compounds were not detected in the site samples, with the exception of one magazine floor soil sample and one wipe sample (AS-MG02-01 and AS-WP02-01) collected from the mid-sized magazine (Building 2950). RDX was detected in soil sample AS-MG02-01 at a concentration of 410 mg/kg, which exceeds the MTCA Method B criterion of 9.09 mg/kg. RDX was also detected at an estimated concentration of 1.9 micrograms/sample in wipe sample AS-WP02-01. Trace levels of several other nitroaromatic and nitramine explosives also were detected in these two samples. PETN also was detected in magazine soil sample AS-MG02-01, at a concentration of 9.4 mg/kg. No screening levels are available for PETN. PA was not detected in any of the soil or wipe samples; however, results of the PA analyses were rejected for the two soil boring samples (AS-SB01-01 and AS-SB02-01) because the laboratory QC data did not meet the required criteria.

Analytes detected at elevated concentrations in most or all of the surface soil samples collected outside of the magazines included arsenic, barium, beryllium, cadmium, chromium, copper, and nickel. All of these metals were detected at concentrations exceeding both background and one or more of the regulatory/risk-based criteria. However, only arsenic and beryllium were detected

at concentrations exceeding the human health, risk-based screening criteria. One surface soil sample also contained thallium, and two contained zinc at concentrations above regulatory criteria; both of these metals were detected at concentrations above the MTCA Method B criterion for the protection of groundwater, as well as above background concentrations.

In contrast, the only metal detected in a subsurface soil sample at a concentration above screening criteria and background levels was thallium, which was detected in sample AS-SB01-01 (collected from 2.5 feet bgs) at a concentration of 0.33 mg/kg, slightly exceeding the background concentration of 0.27 mg/kg. This concentration exceeds the MTCA Method B groundwater protection criterion. In general, the metals concentrations decreased significantly with depth, based on a comparison of the results of the surface sample (AS-SS10-01) and the two subsurface soil samples collected from the same location (AS-SB01-01 at 2.5 feet bgs and AS-SB01-02 at 6 feet bgs).

6.14.5 Discussion of Results

Concerns at the Ammunition Storage Magazine site included the potential presence of residues from handling and storage of ammunition used at the facility. Areas of potential concern included the magazine interiors and soil surrounding the magazines. Contaminants released during ammunition storage within the magazines would typically be contained. Contaminants released during ammunition handling outside of the magazines could either impact underlying soil or migrate via surface water runoff. Contaminants in surface soil can migrate to subsurface soil and to groundwater. Groundwater was not encountered during drilling and sampling at the site; however, weathered volcanic rock was encountered at a depth of approximately 7 feet bgs. Lacamas Creek is located immediately south of the Ammunition Storage Magazine site; both groundwater and surface water runoff are expected to flow toward the creek.

Surface and subsurface soil samples were collected for analysis from the site. In addition, soil and wipe samples were collected from the interiors of the three magazines. Existing soil and residues within the magazines contain elevated concentrations of metals and RDX. Results of surface soil sampling indicated the presence of elevated concentrations of metals (exceeding one or more of the regulatory screening levels and background) over much of the site. Results of analysis of two deeper soil samples indicated that contaminant concentrations were significantly reduced with depth. In subsurface soil, only thallium was detected at a concentration exceeding one of the regulatory/risk-based screening criteria and slightly above background (but less than two times background) in one sample.

Potential exposure routes include ingestion and dermal contact with contaminated soil, groundwater, surface water, and sediments. Potential receptors at this site include site workers and visitors, as well as terrestrial and aquatic biota.

6.15 HAZARDOUS MATERIAL ACCUMULATION POINT

6.15.1 Site Characteristics

The Hazardous Material Accumulation Point, Building 4476, is located in the northeast corner of the Camp Bonneville shop area, in the Camp Killpack cantonment (Figure 6-5). The building is a three-walled structure, built in 1990, with cement masonry block walls and a concrete slab floor. The open front of the structure is secured with locking metal gates. The structure, also referred to as the Covered Vehicle Maintenance Storage, has been used for the storage of drums of liquids such as antifreeze and waste oil. It may have been used for temporary storage of drums of other hazardous materials. The structure currently is used for empty drum storage. The concrete floor of the building is sloped toward a sump in the middle of the floor. The sump measures approximately 2 feet square and is approximately 2 feet deep. No drains are present in the sump. No evidence or reports of spills at this site were found.

The Hazardous Material Accumulation Point is bounded by a gravel driving surface to the south and east, small storage buildings and equipment to the west, and woods to the north. A vehicle fuel AST, covered and within a concrete containment structure, is located immediately west of the building. The chain-link fence that surrounds the shop office area runs along the north and east sides of the building. The site area is fairly flat. Drainage from the area likely flows to the ditch running parallel to the main access road, south of the fenced shop area. Photographs of the site are provided in Appendix A.

6.15.2 Site Investigations

Surface soil samples were collected on February 27, 1998, from two locations directly in front of the Hazardous Material Accumulation Point building. Sample HM-SS-01-01 was collected directly in front of the building, approximately 10 inches from the edge of the concrete floor pad. Sample location HM-SS-02 also was collected directly in front of the building, west of sample HM-SS-01-01. The samples were collected from approximately 0 to 6 inches bgs. A duplicate/split sample and MS/MSD samples were collected from location HM-SS-01.

A sample of the liquid in the sump was collected for analysis. Initially, the sample was collected as described in the Management Plan, using a disposable bailer for collection of the VOCs and a scoop for the other analyses. Following sample collection, the liquid in the sump was pumped into a 55-gallon drum. At that point, a thin layer of sediment/sludge (approximately 1 inch thick) remained in the bottom of the sump, with a small amount of what appeared to be petroleum product seeping out. The sludge was scooped out and placed into the drum. The initial liquid sample was poured out, and a second sample of the mixed liquid and sludge from the drum was collected in new, clean containers to provide a more representative sample of the material for disposal purposes.

6.15.3 Field Observations

The soil encountered from 0 to 6 inches bgs in both sample locations was fill material consisting of dense, moist, brown, silty, clayey gravel with scattered roots. PID headspace screening was conducted on both samples. The PID results were 13.2 ppm for sample HM-SS-01-01 and 23 ppm for sample HM-SS-02-01. No odor or staining was observed in the samples.

After the contents of the sump were removed, the sump was visually inspected for any evidence of cracks or outlets where leaking or discharges from the sump could occur. The concrete was observed to be in good condition, with no pipes or outlets evident.

6.15.4 Analytical Results

6.15.4.1 Soil

Two surface soil samples and one duplicate/split sample were collected from the Hazardous Materials Accumulation Point area. These samples were analyzed for TPH, SVOCs, PCBs/pesticides, and priority pollutant metals. The results of these analyses are summarized in Table 6-15 and described in this section.

Sample HM-SS-01-01 and the duplicate sample contained TPH (identified as unknown hydrocarbons and quantitated in the diesel range) at concentrations well below MTCA Method A cleanup levels. The only other organic constituent detected in the soil samples was bis(2-ethylhexyl)phthalate. This SVOC was detected only in the duplicate sample, at a concentration of 0.033 mg/kg, which is below the regulatory screening criterion. This detection may be due to laboratory or sampling contamination, since phthalates are common laboratory and field sampling contaminants. Metals detected in the surface soil samples included antimony, barium, cadmium, chromium, copper, lead, nickel, silver, and zinc, all at concentrations below regulatory screening criteria. Arsenic and beryllium were detected at concentrations exceeding regulatory screening criteria but well below background levels.

6.15.4.2 Sump

One liquid sample was collected from the sump and analyzed for TPH, SVOCs, VOCs, PCBs/pesticides, and metals. Results of the analyses are summarized in Table 6-11. Unknown hydrocarbons were detected at an estimated concentration of 51 mg/L, which exceeds the MTCA Method A value of 1 mg/L for groundwater. A review of the chromatogram for this sample indicated that some of the compounds fell within the diesel range (C_{10} to C_{24}) and some were heavier (the sample range equaled C_{16} to C_{40}). The substance appears to be a weathered oil-based product or weathered diesel-oil mixture. Bis(2-ethylhexyl) phthalate, the only other organic analyte detected, was initially measured at a concentration of 52 mg/L, and upon reextraction and reanalysis, was reported at 10 mg/L. Both concentrations exceeded MTCA Method B and EPA Region 3 screening criteria for groundwater. Antimony, arsenic, beryllium, lead, and zinc were detected at concentrations above the groundwater screening criteria.

6.15.5 Discussion of Results

The Hazardous Material Accumulation Point building is currently used for empty drum storage. The building has a sloping floor that drains to a sump. Spills within the building would drain to the sump. The sump was cleaned out during the investigation and the contents were disposed of off site. No evidence of significant contamination was found in the material removed. In addition, no cracks or outlets were observed within the sump, which could allow the release of contaminants. Contaminants released during handling of drums outside of the building could either enter underlying soil or migrate via surface water runoff. Surface water runoff from the site likely flows to the south to a ditch on the north side of the facility access road, then toward a small stream immediately west of the shop office.

Two surface soil samples were collected from in front of the Hazardous Material Accumulation Point building. No constituents were detected at concentrations above the regulatory/risk-based screening criteria and background levels (where applicable).

6.16 FORMER CS TRAINING BUILDING

6.16.1 Site Characteristics

The Former CS Training Building was located south of the Camp Bonneville cantonment, between Lacamas Creek on the north and the 50-caliber firing range (Firing Range 7) on the south. The approximate location of the former building is indicated on Figure 6-8. The exact location and dimensions of the building are not known, nor is its period of use. The wood building was destroyed by fire on an unspecified date in the late 1970s. Several aerial photographs taken in 1950, 1960, and 1970 appear to indicate the presence of a small building in the approximate location indicated on Figure 6-8. The Former CS Training Building has been designated BRAC parcel number 25(7)HR(P).

The Former CS Training Building was used for military training to provide troops with confidence in the use of chemical warfare protective equipment. The primary substance released in the building during training exercises was CS gas (tear gas). CS is the common name for 2-chlorobenzalmalononitrile (CAS: 2698-41-1; synonyms are: o-chlorobenzalmalononitrile and o-chlorobenzylidene). CS is typically used as a military or police riot-control agent, and for training exercises. CS gas decomposes rapidly with no persistent metabolites when burned and exposed to water. However, no environmental sampling had been performed at the site for use in evaluating the environmental condition of the property.

According to the Corps, available information regarding the building construction indicates that asbestos is not a concern. However, it is reasonable to expect that lead-based paint may have been used on the building. Residues from the paint may have been released to the soil over the life of the building and when it burned. Semivolatiles may also have been present in the building materials, or may be present as a result of combustion of the materials.

The EBS reported that "there is a potential for chemical [warfare recognition] kits to be buried near the [former] building [location]." However, the Archives Search Report (ASR) (Corps, 1997a), a survey of military records regarding the use of munitions and warfare agents at Camp Bonneville, failed to substantiate this potential, and indicated that all chemical warfare agents shipped to the site for training purposes appear to have been used (Corps, 1998a). Therefore, it is assumed that there are no chemical warfare kits at this site.

The former building site is bounded by Lacamas Creek to the north and a dirt road (blocked off) to the south. The site and adjacent areas to the east and west are open and covered with grass. A power pole (no longer in use) exists in the site area. The site area is generally flat, with little slope. The elevation drops off several feet at the steep creek bank on the northern side of the site. Ruts in the roadway held several inches of water during a site visit in March 1998, although the majority of the site appeared dry. Photographs of the site are provided in Appendix A.

6.16.2 Field Investigations

UXO avoidance work was performed at the site before initiating sampling. Two roughly parallel linear magnetic anomalies were detected, aligned generally with the assumed locations of the north and south sides of the former building. One of these lines appears to be a former communications cable. The trace of the other line was somewhat irregular. A north-south-oriented culvert, which connects a ditch to Lacamas Creek, was found near the assumed west side of the former building.

Soil samples were collected from five locations (see Figure 6-8) on July 13 and 14, 1998. Samples were collected from approximately 0 to 6 inches bgs and from 2 to 3 feet bgs at each location. Duplicate/split samples and MS/MSD samples were collected from location CS-SB05-02. All soil samples were collected using a hand auger. Duplicate/split and MS/MSD samples were co-located (adjacent holes) but homogenized together.

The surface soil samples were analyzed for more constituents than the deeper samples, except in location CS-SB05, where buried debris was encountered beneath the surface. In that location, the more extensive analysis was performed on the deeper sample, because it appeared to have a greater likelihood of being contaminated.

6.16.3 Field Observations

PID screening was conducted on all soil samples and boreholes during sample collection and hand augering. All PID results were less than 1 ppm with the exception of samples CS-SB01-02 and CS-SB02-01, in which PID results were 7 ppm and 2 ppm, respectively. The PID readings from these two samples are relatively low and may be due to natural organics present in the soils.

Soil types encountered at this site include medium dense to dense, moist, dark brown, silty clay/clayey silt, with numerous roots and occasional iron staining. Debris was encountered starting about 6 inches bgs in boring CS-SB05, located near the estimated center of the former

building area. The debris included charred wood and metal (nails, wire, and a piece of pipe). An attempt was made to auger down to the base of the material to determine its thickness; however, a large sheet of wood (with green paint) was encountered in several attempted holes. The auger could not be advanced past this material at about 3.5 feet bgs.

6.16.4 Analytical Results

Five soil borings were drilled at the Former CS Training Building site, and ten soil samples plus one duplicate/split sample were collected. All samples were analyzed for CS gas (using a modified version of method SW8270) and cyanide. One sample from each boring was also analyzed for SVOCs and lead. The results of these analyses are summarized in Table 6-16 and discussed in this section.

CS gas and its breakdown products were not detected in any of the samples. Cyanide also was not detected in any of the samples. SVOCs were detected in four of the five soil samples submitted for analysis (and in the duplicate sample). Of the seven SVOCs detected, only benzo(b)fluoranthene was detected at a concentration exceeding any of the regulatory screening criteria. Benzo(b)fluoranthene was detected in two samples (CS-SB03-01 and CS-SB04-01) at concentrations above the MTCA Method B groundwater protection level of 0.0012 mg/kg. The other SVOCs detected include n-nitrosodiphenylamine (CS-SB01-01 and CS-SB03-01); bis(2-ethylhexyl)phthalate (CS-SB03-01 and CS-SB04-01); 2,4-dinitrotoluene (CS-SB03-01); 2,6-dinitrotoluene (CS-SB03-01); di-n-butyl phthalate (CS-SB06-02); and pyrene (CS-SB05-02). Lead was detected in all five samples analyzed, and in the duplicate sample. Lead was detected in two of the samples at concentrations exceeding the MTCA Method A cleanup level of 250 mg/kg; one of these samples also exceeded the EPA Region 3 criterion. Sample CS-SB03-01 contained lead at a concentration of 674 mg/kg, and sample CS-SB04-01 contained lead at a concentration of 278 mg/kg.

6.16.5 Discussion of Results

The apparent location of the Former CS Training Building was determined based on remaining site features including a power pole, an underground cable, and a generally linear magnetic anomaly that coincided with an assumed edge of the former building. Contaminants released from the building or during combustion of the building would either enter underlying soil or migrate via surface water runoff. Shallow buried debris, including charred wood and metal, was found in the approximate center of the apparent former building location. Contaminants in shallow soil can migrate to subsurface soil and shallow groundwater. Groundwater was not encountered during sampling at the site (to 3.5 feet bgs), but is expected to occur at a shallow depth. Both surface water and shallow groundwater from the site area are assumed to flow to the north and to discharge to Lacamas Creek, located adjacent to the site.

Surface and near-surface soil samples were collected for analysis from locations within the apparent building footprint. Constituents detected in surface soil at concentrations exceeding one or more of the regulatory/risk-based screening criteria (and background, where applicable)

included lead and one SVOC (benzo[b]fluoranthene). No constituents were detected at levels exceeding the screening criteria in a near-surface sample of the buried debris. Analysis of the other near-surface soil samples was limited to CS and its breakdown products.

Potential exposure routes include ingestion and dermal contact with contaminated soil, groundwater, surface water, and sediments. Potential receptors include site workers and visitors, and terrestrial and aquatic biota.

6.17 WASH RACK NO. 2

6.17.1 Site Characteristics

The former Wash Rack No. 2 site (or former maintenance rack site) is located in the Camp Killpack cantonment at the northeast corner of the shop office area, near Building 4476 (the Hazardous Material Accumulation Point) (Figure 6-5). This site has been designated BRAC parcel number 14(7)PR(P)/HR(P).

According to the EBS, the site was located either just east of Building 4476 or in approximately the same location as the building. However, more recent conversations with a representative of the Corps indicated that the site is located behind (north of) Building 4476, on the hillside in a small, relatively level clearing (Corps, 1998b). This information was based on previous conversations between the Corps representative and the former Facility Manager. During a site visit in March 1998, most of the site area was covered by ponded water at depths up to more than a foot.

The Wash Rack No. 2 site has been referred to as both a vehicle wash rack (Woodward-Clyde, 1996) and a vehicle maintenance rack (Woodward-Clyde, 1997). According to the EBS, this rack was used for vehicle maintenance, including the draining of engine fluids. The rack was reportedly constructed of two parallel timber ramps, with gravel between. If vehicles were washed at the site, the wash water would have discharged, by uncontrolled overland flow, onto the surrounding area. Contaminants from such a site could include vehicle fluids (such as gasoline, waste oil, lubricants, and antifreeze), metals from gasoline and waste oil, and solvents used during cleaning activities. No visible signs of contamination have been noted at the site.

According to the EBS, the wash rack was demolished in the 1980s. An adjacent UST reportedly was removed in 1978, when the Hazardous Material Accumulation Point building was constructed. No evidence of contamination was detected during the diesel tank removal activities. No documentation of this wash rack was found during the records review for the EBS; the information provided in that document reportedly was obtained during an interview with the former Facility Manager. Photographs of the site are provided in Appendix A.

6.17.2 Site Investigations

Surface and near-surface soil samples were collected from two locations at the site on July 27, 1998. Samples were collected from approximately 0 to 6 inches bgs and from 2 to 3 feet bgs at each location. A duplicate sample was collected at location W2-SB02-01. All soil samples were collected using a hand auger. Samples for the duplicate were co-located (adjacent holes) but homogenized together.

6.17.3 Field Observations

The site area was dry at the time of the investigation. Soils encountered in the shallow borings at this site consist of gravelly, clayey silt to silty clay with scattered roots and occasional iron staining. No visual evidence of contamination was observed, nor were odors or elevated PID readings detected in the borings. All PID results were less than 1 ppm.

6.17.4 Analytical Results

Four soil samples and one duplicate/split sample were collected from the Wash Rack No. 2 site. All samples were analyzed for TPH, SVOCs, and priority pollutant metals. The results of these analyses are summarized in Table 6-17 and discussed in this section.

TPH was detected at estimated concentrations well below the MTCA Method A cleanup levels in all four samples; however, the chromatogram profiles were not consistent with the fuel standards. No SVOCs were detected in any of the samples. Arsenic, barium, beryllium, chromium, and copper were detected at concentrations exceeding one or more of the regulatory screening criteria in most or all samples; however, all results were below background levels. Antimony, cadmium, lead, nickel, silver, zinc, and mercury were detected in one or more samples at concentrations below regulatory and background screening criteria.

6.17.5 Discussion of Results

The vehicle wash rack at the Wash Rack No. 2 site has been removed. Spills or discharges from the Wash Rack No. 2 site could either impact underlying soil or migrate via surface water runoff. The site area slopes generally to the south toward a ditch along the facility access road, and to the west toward a small stream that flows under the shop office area and resurfaces adjacent to the existing Wash Rack (No. 1).

Surface and near-surface soil samples were collected for analysis from the apparent former site area. No constituents were detected at concentrations above the regulatory/risk-based screening criteria and background levels (where applicable) in the soil samples.

6.18 SUMMARY OF DATA QUALITY AND COMPLETENESS

Laboratory analytical data were evaluated with respect to quality assurance objectives for precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters and sensitivity. The data quality evaluation presented in Appendix G indicates that most analytical results are acceptable for use without qualification. Some individual sample results were qualified as estimated values, and a few results were rejected. The target for completeness for each method was achieved, except for picric acid. Considerable difficulty was encountered with this method, and consultation between the Corps project chemist, a research chemist with the Corps Cold Regions Research and Engineering Laboratory, Shannon & Wilson's project chemist, and the laboratory's chemist and project manager took place and resulted in the flagging of results for several samples. Other results were rejected because several QC criteria were lower than those agreed upon during the discussion. PA results were rejected for the following samples: AS-SB01-01, AS-SB02-01, DB-SB01-01, DB-SB02-01, PD-SB02-01, PD-SB03-01, PD-SB04-01, and PD-SB05-01. Antimony results were rejected for two samples (BA-SS05-01 and BK-SS04-01); however, the overall completeness goal for method SW6020 was still met.

Where analytes were detected in both samples of a field duplicate pair, the relative percent difference was calculated and compared with QAPP acceptance criteria. The project specifications were met for most of these analytes, indicating that the sampling and analysis procedures were reproducible. Further details of these evaluations are provided in Appendix G.

TABLE 6-1
GROUNDWATER FIELD PARAMETERS AND WATER LEVELS
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Well Number	Ecology Well Designation	Date Sampled	Volume Purged (gallons)	Purging Method	Groundwater Sample Number	Field Parameters at Time of Sampling					
						pH	Temperature (˚Celcius)	Specific Conductance (mmhos/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Color
L2-MW01	AEA 936	8/4/1998	9	Grundfos pump	L2-MW01-01	6.58	13.7	250	0.79	11.5	Very light orange
L2-MW02	AEA 935	8/6/1998	5.8	Grundfos pump	L2-MW02-01	6.62	12.4	144	6.97	2.1	Clear
L3-MW01	AEA 933	8/3/1998	7.5	Grundfos pump	L3-MW01-01	7.03	11.9	160	0.06	2.1	Clear
L3-MW02	AEA 932	8/4/1998	9	Grundfos pump	L3-MW02-01	6.69	11.3	140	0.13	1.1	Clear
L3-MW03	AEA 934	8/4/1998	6.6	Grundfos pump	L3-MW03-01	6.74	13.1	147	0.13	2.4	Clear
L3-MW04	AEA 931	8/6/1998	10.8	Grundfos pump	L3-MW04-01	5.22	15.7	64	0.09	22	Very light orange
SP-MW01	AEA 926	8/6/1998	9.7	Grundfos pump	SP-MW01-01	6.34	14.0	227	0.82	2.9	Clear
SP-MW02	AEA 929	8/5/1998	10	Grundfos pump	SP-MW02-01	6.11	15.0	210	0.42	24	Clear
PM-MW01	AEA 927	8/5/1998	6.5	Bailer	PM-MW01-01	6.58	12.8	279	6.2	88	Clear
PM-MW02	AEA 928	8/5/1998	5.2	Bailer	PM-MW02-01	6.20	11.7	221	7.1	29	Clear

Well Number	Measuring Point Elevation (feet)	Depth to Water[a] (feet)		Water Elevation (feet)		
		8/3/1998	########	8/3/1998	12/16/1998	Change
L2-MW01	339.18	5.72	4.66	333.46	334.52	1.06
L2-MW02	338.56	5.81	5.13	332.75	333.43	0.68
L3-MW01	340.32	7.12	6.22	333.20	334.10	0.9
L3-MW02	340.89	7.48	6.25	333.41	334.64	1.23
L3-MW03	340.58	7.08	6.22	333.50	334.36	0.86
L3-MW04	341.16	5.73	4.47	335.43	336.69	1.26
SP-MW01	332.99	6.61	4.32	326.38	328.67	2.29
SP-MW02*	337.16	7.81	5.20	329.35	331.96	2.61
PM-MW01*	367.67	19.72	17.38	347.95	350.29	2.34
PM-MW02	356.36	12.26	10.19	344.10	346.17	2.07

Notes: [a] = below top of casing (measuring point)
µmhos/cm = micromhos per centimeter
mg/L = milligrams per liter
NTU = Nephelometric turbidity units

TABLE 6-2
LANDFILLS 2 AND 3, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

		Sample Concentration									Regulatory/Risk-Based Criteria				
Parameter	**Units**	L2-SB01-01	L2-SB02-01	L2-SB03-01	L3-SB01-01	L3-SB02-01	L3-SB03-01	L3-SB04-01	L3-SB05-01	L3-SB06-01	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	**Background**
										(dup SB02-01)					
Sample Date		7/14/1998	7/15/1998	7/17/1998	7/14/1998	7/15/1998	7/15/1998	7/16/1998	7/16/1998	7/15/1998					
Sample Depth	ft bgs	2.0	2.0	3.0	4.0	3.0	4.0	3.2	2.0	3.0					
TPH	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND					
VOCs	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND					
SVOCs	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND					
PCBs/Pesticides	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND					
Explosives	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND					
PETN	mg/kg	0.22 J	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	
PA	mg/kg	ND J-	ND J-	ND J-	ND J-	ND J-	ND J-	ND J-	ND J-	ND J-	NA	NA	NA	NA	
Cyanide	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND					
Metals															
Antimony	mg/kg	0.058 J	0.066 J	0.064 J	0.064 J-	0.056 J	0.042 J	0.079 J	0.062 J	0.065 J	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**3.9**	**3.5**	**4**	**3.8**	**3.2**	**4.5**	**3.8**	**3.5**	**3.6**	20	1.67	0.005	0.43	7
Barium	mg/kg	**253**	**194**	**255**	**196J**	**196**	**168**	**205**	**165**	**208**	NA	5,600	112	5,500	257
Beryllium	mg/kg	**1.1**	**1.2**	**1.1**	**1.3**	**1.2**	**1.1**	**1.2**	**0.98**	**1.2**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	0.13 J	0.12 J	0.062 J	0.10 J	0.12 J	0.077 J	0.091 J	0.12 J	0.12 J	2	80	1.6	39	1
Chromium	mg/kg	**26.7**	**22.3**	**29.2**	**26.8 J+**	**26.7**	**23.6**	**23.4**	**24.2**	**29.3**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	**81.1**	**78.7**	**134**	**90**	**73.9**	**79.3**	**91.7**	58.5	**79.7**	NA	2,960	59.2	3,100	114
Lead	mg/kg	9.1	5.8	7	6.5	6.2	4.3	6.7	13.1	6.1	250	NA	NA	400[d]	17
Nickel	mg/kg	12.7	11.2	14	12.7	10.8	10.8	12.3	11.1	12.1	NA	1,600	32	1,600	38
Selenium	mg/kg	ND	ND	ND	ND	ND	ND	ND	0.10 J	ND	NA	400	8	390	NA
Silver	mg/kg	0.19 J	0.14 J	0.24 J	0.18 J	0.17 J	0.19 J	0.20 J	0.16 J	0.18 J	NA	400	8	390	NA
Thallium	mg/kg	**0.14 J**	**0.16 J**	**0.13 J**	**0.16 J**	**0.13 J**	ND	ND	**0.13 J**	**0.13 J**	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	92.3 B	71.9 BJ	53.9 B	78.1 BJ	14.2 BJ	54 B	66 B	60.6 B	77.3 BJ	NA	24,000	480	23,000	86
Mercury	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	24	24	7.8[f]/23[g]	0.07
TOC	mg/kg	1.2	1.3	0.36	1.3	1.3	1.1	0.62	1.1	1.2	NA	NA	NA	NA	

Notes:

This table includes only those constituents detected in the samples.

Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes and acronyms.

TABLE 6-3
LANDFILLS 2 AND 3, CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration							Regulatory/Risk-Based Criteria			
		L2-MW01-01	L2-MW02-01	L3-MW01-01	L3-MW02-01	L3-MW03-01	L3-MW03-02	L3-MW04-01	MCL	MTCA A	MTCA B	EPA Reg. 3
		Downgradient	Downgradient	Downgradient	Downgradient	Downgradient	(dup MW03-01)	Upgradient				
Sample Date		8/4/1998	8/4/1998	8/4/1998	8/4/1998	8/4/1998	8/4/1998	8/4/1998				
TPH	mg/L	ND	ND	ND	ND	ND	ND	ND				
VOCs												
Naphthalene	µg/L	ND	0.32 J	ND	0.36 J	ND	ND	ND	NA	NA	320	1,500
SVOCs	µg/L	ND	ND	ND	ND	ND	ND	ND				
Explosives	µg/L	ND	ND	ND	ND	ND	ND	ND				
PETN	µg/L	ND	ND	ND	ND	ND	ND	ND				
PA	µg/L	ND	ND	ND	ND	ND	ND	ND				
PCBs/Pesticides	µg/L	ND	ND	ND	ND	ND	ND	ND				
Cyanide	mg/L	ND	ND	ND	ND	ND	ND	ND	0.2	NA	0.32	0.18-7.3
Metals-Total												
Antimony	mg/L	ND	ND	ND	ND	ND	ND	ND	0.006	0.0014 - 0.008[a]	0.0014 - 0.008[a]	0.015
Arsenic	mg/L	**0.00053 J**	**0.00072 J**	**0.0035**	**0.0015 J**	**0.0011 J**	**0.00086 J**	ND	0.05	0.005	0.00005	0.000045
Barium	mg/L	0.038	0.00057 J	0.00085 J	0.0024	0.0051	0.0055	0.014	2	1.12	1.12	2.6
Beryllium	mg/L	ND	ND	ND	ND	ND	ND	ND	0.004	0.0000203	0.0000203	0.000016
Cadmium	mg/L	ND	ND	ND	ND	ND	ND	ND	0.005	0.008	0.008	0.018
Chromium	mg/L	0.0019	0.0019	0.00057 J	0.00074 J	0.0021	0.0016	0.00056 J	0.1	16[b] (0.08)[c]	16[b] (0.08)[c]	37[b] (0.18)[c]
Copper	mg/L	0.0017	0.00047 J	0.0014	0.00035 J	0.0042	0.0044	0.0027	1.3	0.592	0.592	1.5
Lead	mg/L	0.00031 J	ND	ND	0.00015 J	0.00024 J	0.00027 J	0.00031 J	0.015	NA	NA	0.015
Nickel	mg/L	0.0011	0.0011	0.00027 J	0.00033 J	0.00095 J	0.00093 J	0.00088 J	0.1	0.32	0.32	0.73
Selenium	mg/L	0.00019 J	ND	ND	0.00012 J	ND	ND	ND	0.05	0.08	0.08	0.18
Silver	mg/L	ND	ND	ND	ND	ND	ND	ND	NA	0.08	0.08	0.018
Thallium	mg/L	ND	0.00013 J	0.00022 J	0.00026	ND	ND	ND	0.002	0.00112	0.00112	0.0029-0.0033
Zinc	mg/L	0.0032 J	0.0017 J	0.0027 J	0.0025 J	0.0029 J	0.0039 J	0.0025 J	NA	4.8	4.8	11
Mercury	mg/L	ND	ND	ND	ND	ND	ND	ND	2	4.8	4.8	11[g]/3.7[f]

TABLE 6-3
LANDFILLS 2 AND 3, CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration							Regulatory/Risk-Based Criteria			
		L2-MW01-01	L2-MW02-01	L3-MW01-01	L3-MW02-01	L3-MW03-01	L3-MW03-02	L3-MW04-01	MCL	MTCA A	MTCA B	EPA Reg. 3
Metals-Dissolved												
Antimony	mg/L	ND	ND	0.00020 J	ND	ND	ND	ND	0.006	0.0014 - 0.008[a]	0.0014 - 0.008[a]	0.015
Arsenic	mg/L	**0.00053 J**	**0.00083 J**	**0.0035**	**0.0016 J**	**0.00089 J**	**0.0010 J**	ND	0.05	0.005	0.00005	0.000045
Barium	mg/L	0.032	ND	0.00046 J	0.0022	0.0021	0.0019	0.0093	2	1.12	1.12	2.6
Beryllium	mg/L	ND	ND	ND	ND	ND	ND	ND	0.004	0.0000203	0.0000203	0.000016
Cadmium	mg/L	ND	ND	ND	ND	ND	ND	ND	0.005	0.008	0.008	0.018
Chromium	mg/L	0.0019	0.0011	0.00062 J	0.00079 J	0.00089 J	0.00056 J	0.00042 J	0.1	16 [b] (0.08)[c]	16 [b] (0.08)[c]	37[b] (0.18)[c]
Copper	mg/L	0.0047	0.0022	0.0063	0.0013	0.00093 J	0.0013	0.0030	1.3	0.592	0.592	1.5
Lead	mg/L	ND	ND	ND	ND	ND	ND	ND	0.015	NA	NA	0.015
Nickel	mg/L	0.0016	0.0013	0.0015	0.00053 J	0.00063 J	0.00060 J	0.0012	0.1	0.32	0.32	0.73
Selenium	mg/L	ND	ND	ND	ND	ND	ND	ND	0.05	0.08	0.08	0.18
Silver	mg/L	ND	ND	ND	ND	ND	ND	ND	NA	0.08	0.08	0.018
Thallium	mg/L	ND	ND	0.00011 J	0.00015 J	ND	ND	ND	0.002	0.00112	0.00112	0.0029-0.0033
Zinc	mg/L	0.0043 J	0.0022 J	0.0031 J	0.0017 J	0.0038 J	0.0012 J	0.0019 J	NA	4.8	4.8	11
Mercury	mg/L	ND	ND	ND	ND	ND	ND	ND	2	4.8	4.8	11[g]/3.7[f]

Notes:

This table includes only those constituents detected in the samples.

Shading indicates that the value exceeds one or more regulatory criteria.

See Table 6-17 for additional notes and acronyms.

TABLE 6-4
BURN AREA, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration											Regulatory/Risk-Based Criteria				Background
		BA-SS-01-01	BA-SS-01-02	BA-SS-02-01	BA-SS-02-02	BA-SS-03-01	BA-SS-03-02	BA-SS-04-01	BA-SS-04-02	BA-SS-05-01	BA-SS-05-02	BA-SS-06-01	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
												dup of SS03-01					
Sample Date		12/16/1997	12/16/1997	12/16/1997	12/16/1997	12/16/1997	12/16/1997	12/16/1997	12/16/1997	12/16/1997	12/16/1997	12/16/1997					
Sample Depth	ft bgs	0.2	1.2	0.2	1.2	0.3	1.2	0.2	1.5	0.2	1.2	0.3					
TPH	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100/200	NA	NA	NA	
VOCs																	
Acetone	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	.013 J	ND	NA	8,000	80	7,800	
Toluene	mg/kg	ND	ND	ND	.0020 J	ND	ND	ND	ND	ND	.00072 J	ND	40	16,000	160	16,000	
m- & p-xylenes	mg/kg	.0025 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20	160,000	1,600	160,000	
o-xylene	mg/kg	ND	ND	ND	.0026 J	ND	ND	ND	ND	ND	.0012 J	ND	20	160,000	1,600	160,000	
SVOCs	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
PCBs/Pesticide	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
Explosives	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
PETN	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
PA	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
Metals																	
Antimony	mg/kg	0.078	0.058	0.065	0.064	0.052	0.095	0.054	0.074	0.10 R	0.064	0.05	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**2.7**	**2.2**	**3.4**	**3**	**2.2**	**2.8**	**2.1**	**2.8**	**2.8**	**2.6**	**2.3**	20	1.67	0.005	0.43	7
Beryllium	mg/kg	**0.97**	**1.2**	**1.1**	**1.3**	**1.2**	**0.94**	**1.1**	**0.95**	**1.2**	**1**	**1.2**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	0.14	0.11	0.19	0.15	0.16	0.064	0.15	0.082	0.18	0.11	0.16	2	80	1.6	39	1
Chromium	mg/kg	**29.2**	**30.1**	**28.5**	**30.1**	**29**	**30.5**	**26.3**	**30**	**33.8**	**29.7**	**29.2**	100	80,000[b]/400	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	**73.4**	**73**	**89.8**	**91.5**	**90.4**	**99.6**	**90.8**	**104**	**95.3**	**100**	**91.3**	NA	2,960	59.2	3,100	114
Lead	mg/kg	14.8	9.8	13.1	9	8.9	7.4	11.1	9.6	17.9	11	9.2	250	NA	NA	400[d]	17
Nickel	mg/kg	15.1	12.3	14.5	15	11.7	13.1	11.7	14.2	13.1	12.9	12.1	NA	1,600	32	1,600	38
Selenium	mg/kg	0.11	ND	ND	ND	ND	ND G	ND	0.23 G	ND	0.027	ND G	NA	400	8	390	NA
Silver	mg/kg	0.19	0.21	0.23	0.25	0.25	0.24	0.26	0.23	0.24	0.25	0.26	NA	400	8	390	NA
Thallium	mg/kg	**0.17**	ND	ND	ND	ND	ND	ND	0.015	**0.29**	0.037	ND	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	86.1	76.4	96.1	91.9	182	83	91.9	74.5	99.7	87	166	NA	24,000	480	23,000	86
Mercury	mg/kg	.053 J	.044 J	.062 J	.070 J	.050 J	.049 J	.056 J	.046 J	.064 J	.050 J	.047 J	1	24	24	7.8[f]/23[g]	0.07

Notes:

This table includes only those constituents detected in the samples.

Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes and acronyms.

TABLE 6-5
FORMER BUILDINGS 1962 AND 1983, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration										
		BD-SS01-01	BD-SS02-01	BD-SS03-01	BD-SS04-01	BD-SS05-01	BD-SS06-01	BD-SS06-02	BD-SS06-03	BD-SS07-01	BD-SS07-02	BD-SS08-01
									(dup SS06-01)			
Sample Date		2/25/1998	2/25/1998	2/25/1998	2/25/1998	2/25/1998	2/25/1998	2/25/1998	2/25/1998	2/25/1998	2/25/1998	2/25/1998
Sample Depth	ft bgs	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
Asbestos	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SVOCs	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	mg/kg	24.3	49.2	23.3	37.6	38.6	99.9	11.3	149	99.5	12.4	40.7

Parameter	Units	Sample Concentration					Regulatory/Risk-Based Criteria				Background
		BD-SS08-02	BD-SS09-01	BD-SS09-02	BD-SS10-01	BD-SS10-02	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
Sample Date		2/25/1998	2/25/1998	2/25/1998	2/25/1998	2/25/1998					
Sample Depth	ft bgs	1.0	0.0	1.0	0.0	1.0					
Asbestos	mg/kg	ND	ND	ND	ND	ND					
SVOCs	mg/kg	ND	ND	ND	ND	ND					
Lead	mg/kg	13.3	61.7	14.2	30.2	12.8	250	NA	NA	400[a]	17

Notes:

This table includes only those constituents detected in the samples.

See Table 6-17 for additional notes and acronyms.

TABLE 6-6
DRUM DISPOSAL AREA/PAINT AND SOLVENT DISPOSAL AREA, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration							Regulatory/Risk-Based Criteria				Background
		DB-SB01-01	DB-SB02-01	PD-SB01-01	PD-SB02-01	PD-SB03-01	PD-SB04-01	PD-SB05-01	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
								(dup SB03-01)					
Sample Date		7/22/1998	7/22/1998	7/22/1998	7/22/1998	7/22/1998	7/22/1998	7/22/1998					
Sample Depth	ft bgs	4.0	4.0	3.0	3.0	2.0	2.0	2.0					
TPH													
Unknown Hydrocarbon	mg/kg	47 Y	61 Y	35 Y	15 Y	56 Y	**160 Y**	56 Y	100/200	NA	NA	NA	
VOCs													
Acetone	mg/kg	0.24	ND	ND	ND	ND	ND	ND	NA	8,000	80	7,800	
2-Butanone (MEK)	mg/kg	0.050	ND	ND	ND	ND	ND	ND	NA	48,000	480	47,000	
Ethylbenzene	mg/kg	0.56	ND	ND	ND	ND	ND	ND	20	8,000	80	7,800	
m- & p-Xylenes	mg/kg	3.6 E	ND	ND	ND	ND	ND	ND	20	160,000	1,600	160,000	
o-Xylene	mg/kg	1.3 E	ND	ND	ND	ND	ND	ND	20	160,000	1,600	160,000	
Isopropylbenzene	mg/kg	0.010	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	
n-Propylbenzene	mg/kg	0.0075 J	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	
1,3,5-Trimethylbenzene	mg/kg	0.021	ND	ND	ND	ND	ND	ND	NA	NA	NA	3,900	
tert-Butylbenzene	mg/kg	0.0060 J	ND	ND	ND	ND	ND	ND	NA	NA	NA	780	
1,2,4-Trimethylbenzene	mg/kg	0.054	ND	ND	ND	ND	ND	ND	NA	NA	NA	3,900	
P-cymene (Isopropyltoluene)	mg/kg	0.020	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	
Naphthalene	mg/kg	0.0032 J	ND	ND	ND	ND	ND	ND	NA	32,000	32	3,100	
2-Hexanone	mg/kg	0.032	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	
SVOCs	mg/kg	ND	ND	ND	ND	ND	ND	ND					
PCBs/Pesticides	mg/kg	ND	ND	ND	ND	ND	ND	ND					
Explosives (8330)	mg/kg	ND	ND	ND	ND	ND	ND	ND					
PETN	mg/kg	ND	ND	ND	ND	ND	ND	ND					
PA	mg/kg	ND R	ND R	ND	ND R	ND R	ND R	ND R					
Metals													
Antimony	mg/kg	**0.65 G**	0.053 GJ	0.096 GJ	0.11 GJ	0.12 GJ	0.090 GJ	0.11 GJ	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**2.5 G**	**1.5 G**	**4.2 G**	**5.3 G**	**2.8 G**	**2.7 G**	**3.0 G**	20	1.67	0.005	0.43	7
Barium	mg/kg	**213 G**	**388 G**	64.8 G	79.2 G	**171 G**	**181 G**	**143 G**	NA	5,600	112	5,500	257
Beryllium	mg/kg	**1.3 G**	**0.93 G**	**0.78 G**	**0.87 G**	**1.2 G**	**1.2 G**	**1.1 G**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	0.65 G	1.0 G	0.85 G	1.1 G	0.81 G	0.79 G	1.0 G	2	80	1.6	39	1
Chromium	mg/kg	**22.2 G**	**18.7 G**	**34.7 G**	**26.9 G**	**26.6 G**	**24.3 G**	**25.9 G**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	**88.5 GB**	**125GB**	**73.4 GB**	**79.2 GB**	**66.9 GB**	**66.3 GB**	**75.2 GB**	NA	2,960	59.2	3,100	114

TABLE 6-6
DRUM DISPOSAL AREA/PAINT AND SOLVENT DISPOSAL AREA, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration							Regulatory/Risk-Based Criteria				Background
		DB-SB01-01	DB-SB02-01	PD-SB01-01	PD-SB02-01	PD-SB03-01	PD-SB04-01	PD-SB05-01	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
Lead	mg/kg	13.5 G	7.9 G	13.1 G	13.6 G	14.2 G	13.8 G	13.5 G	250	NA	NA	400[d]	17
Nickel	mg/kg	14.4 G	9.9 G	7.5 G	9.1 G	12.9 G	11.9 G	11.7 G	NA	1,600	32	1,600	38
Selenium	mg/kg	ND G	ND G	ND G	ND G	ND G	ND G	ND G	NA	400	8	390	NA
Silver	mg/kg	0.13 GJ	0.20 GJ	0.15 GJ	0.19 GJ	0.15 GJ	0.13 GJ	0.16 GJ	NA	400	8	390	NA
Thallium	mg/kg	ND G	ND G	ND G	ND G	ND G	ND G	ND G	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	74.7 G	52.7 G	150 G	45.9 G	57.8 G	55.3 G	53.1 G	NA	24,000	480	23,000	86
Mercury	mg/kg	ND	ND	ND	ND	ND	ND	ND	1	24	24	7.8[f]/23[g]	0.07

Notes:

This table includes only those constituents detected in the samples.

Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes.

TABLE 6-7
MAINTENANCE PIT, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration									Regulatory/Risk-Based Criteria				Background
		MP-SB01-01	MP-SB01-02	MP-SB01-03	MP-SB01A-01	MP-SB01A-02	MP-SB01A-03	MP-SB03-01	MP-SB03-02	MP-SB03-03	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
Sample Date		7/22/1998	7/22/1998	7/22/1998	11/19/1998	11/19/1998	11/19/1998	8/3/1998	8/5/1998	8/5/1998					
Sample Depth	ft bgs	0.0	2.5	10.0	0.0	3.5	9.5	0.0	1.5	3.5					
TPH															
Unknown Hydrocarbons	mg/kg	**210 J**	59 J	17 JY	NA	NA	NA	ND	ND	**1000J**	200	NA	NA	NA	
VOCs	mg/kg	NA			NA	NA	NA	NA							
Vinyl chloride	mg/kg		ND	ND					ND	**0.038 J**	NA	0.526	0.0023	0.34	
Acetone	mg/kg		0.052	ND					ND	ND	NA	8,000	80	7,800	
cis-1,2-Dichloroethene	mg/kg		ND	ND					ND	0.063	NA	800	8	780	
m- & p-Xylenes	mg/kg		ND	ND					ND	0.051	20	160,000	1,600	160,000	
0-Xylene	mg/kg		ND	ND					ND	0.044	20	160,000	1,600	160,000	
n-Propylbenzene	mg/kg		ND	ND					ND	0.018 J	NA	NA	NA	NA	
1,3,5-Trimethylbenzene	mg/kg		ND	ND					ND	0.085	NA	NA	NA	3,900	
1,2,4-Trimethylbenzene	mg/kg		ND	ND					ND	0.19	NA	NA	NA	3,900	
Naphthalene	mg/kg		0.0036 J	ND					ND	ND	NA	32,000	32	3,100	
Carbon disulfide	mg/kg		0.0030 J	ND					ND	0.023 J	NA	8,000	80	7,800	
2-Hexanone	mg/kg		ND	ND					ND	0.072 J	NA	NA	NA	NA	
SVOCs					NA	NA	NA								
Diethyl phthalate	mg/kg	ND	ND	ND				0.070 J	ND	ND	NA	64,000	1,280	63,000	
Bis (2-ethylhexyl)phthalate	mg/kg	ND	ND	ND				0.072 J	ND	0.034 J	NA	71.4	0.625	46	
PCBs/Pesticides		NA	NA	NA											
4,4'-DDE	µg/kg				**91J**	0.79J	ND	ND	ND	ND	NA	2,940	25.7	1,900	
4,4'-DDD	µg/kg				**140**	2.7J	ND	ND	ND	ND	NA	4,170	36.5	2,700	
4,4'-DDT	µg/kg				**1000**	16	ND	ND	ND	ND	1000	2,940	25.7	1,900	
Endrin	µg/kg				13GJ	ND	ND	ND	ND	ND	NA	24,000	480	23,000	
Endosulfan sulfate	µg/kg				15GJ	ND	ND	ND	ND	ND	NA	NA	NA	NA	
alpha-Chlordane	µg/kg				**69**	ND	ND	ND	ND	3.1	NA	769[h]	6.73[h]	490[h]	
gamma-Chlordane	µg/kg				**65**	ND	ND	ND	ND	ND	NA	769[h]	6.73[h]	490[h]	
Metals					NA	NA	NA								
Antimony	mg/kg	0.28 GJ	0.064 GJ	0.089 GJ				0.087 J	0.079 J	0.074 J	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**2.4 G**	**3.1 G**	**3.6 G**				**3.5**	**3.8**	**3.4**	20	1.67	0.005	0.43	7
Barium	mg/kg	72.7 G	**165 G**	**176 G**				25.3	64	**155**	NA	5,600	112	5,500	257
Beryllium	mg/kg	**0.36 GJ**	**1.2 G**	**0.67 G**				**0.50**	**0.76**	**1.3**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	0.99 G	0.75 G	1.2 G				0.88	1.1	0.084 J	2	80	1.6	39	1
Chromium	mg/kg	**10.6 GB**	**28.8 GB**	**23.5 GB**				**27.6 B**	**27.8 B**	**37.8 B**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	**63.6 GB**	**90.6 GB**	**149 GB**				51.7	48.9	**70.9**	**NA**	2,960	59.2	3,100	114
Lead	mg/kg	42.7 G	13.1 G	6.3 G				**633**	18.2	61.9	250	NA	NA	400[d]	17
Nickel	mg/kg	9.0 G	7.9 G	9.5 G				8.2	7.7	9.4	NA	1,600	32	1,600	38
Selenium	mg/kg	ND G	0.22 GJ	ND G				0.22 J	0.37 J	0.24 J	NA	400	8	390	NA

TABLE 6-7
MAINTENANCE PIT, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration									Regulatory/Risk-Based Criteria				Background
		MP-SB01-01	MP-SB01-02	MP-SB01-03	MP-SB01A-01	MP-SB01A-02	MP-SB01A-03	MP-SB03-01	MP-SB03-02	MP-SB03-03	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
Silver	mg/kg	0.15 GJ	0.15 GJ	0.24 GJ				0.14 J	0.12 J	0.16 J	NA	400	8	390	NA
Thallium	mg/kg	ND G	ND G	ND G				**0.12 J**	**0.23 J**	**0.26 J**	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	64.3 G	38.2 G	52.1 G				364	324	76.3	NA	24,000	480	23,000	86
Mercury	mg/kg	0.054 J	0.034 J	ND				ND	ND	ND	1	24	24	7.8[f]/23[g]	0.07

Notes:

This table includes only those constituents detected in the samples.

Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes and acronyms.

TABLE 6-8
WASH RACK NO. 1 SITE, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration					Regulatory/Risk-Based Criteria				Background
		WR-SS01-01	WR-SS02-01	WR-SB01-01	WR-SB01-02	WR-SB01-03	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
Sample Date		2/27/1998	2/27/1998	7/22/1998	7/22/1998	7/22/1998					
Sample Depth	ft bgs	0.0	0.0	2.5	5.0	10.0					
TPH											
Unknown Hydrocarbons	mg/kg	**2100 J**	13 J	ND	30 JY	27 JY	200	NA	NA	NA	
VOCs											
Acetone	mg/kg	NA	NA	NA	0.083	ND	NA	8,000	80	7,800	
SVOCs											
Bis(2-ethylhexyl)phthalate	mg/kg	0.19 J	ND	ND	ND	ND	NA	71.4	0.625	46	
Di-n-butyl phthalate	mg/kg	ND	0.075 J	ND	ND	ND	NA	8,000	160	7,800	
PCBs/Pesticides											
4,4'-DDT	mg/kg	0.013 J	0.0012 J	NA	NA	NA	NA	4,170	36.5	2,700	
Alpha Chlordane	mg/kg	0.0022 J	ND	NA	NA	NA	NA	769[h]	6.73[h]	490[h]	
Gamma Chlordane	mg/kg	0.0013 J	ND	NA	NA	NA	NA	769[h]	6.73[h]	490[h]	
Metals											
Antimony	mg/kg	0.26 J	0.11 J	0.062 GJ	0.12 GJ	0.068 GJ	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**3.1**	**2.8**	**2.5 G**	**4.1 G**	**3.4 G**	20	1.67	0.005	0.43	7
Barium	mg/kg	**159**	**205**	**231 G**	**168 G**	**244 G**	NA	5,600	112	5,500	257
Beryllium	mg/kg	**1**	**1.3**	**1.2 G**	**0.67 G**	**0.80 G**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	**1.8**	0.99	ND G	0.70 G	1.1 G	2	80	1.6	39	1
Chromium	mg/kg	**31.6**	**27.2**	**19.7 GB**	**22.6 GB**	**22.9 GB**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	**70.7**	**63.3**	**60.5 GB**	**98.8 GB**	**163 GB**	NA	2,960	59.2	3,100	114
Lead	mg/kg	**766**	45.8	15.8 G	8.5 G	6.5 G	250	NA	NA	400[d]	17
Nickel	mg/kg	8.6	9.8	9.9 G	8.2 G	9.5 G	NA	1,600	32	1,600	38
Selenium	mg/kg	0.55	0.62	0.33 GJ	ND G	0.28 GJ	NA	400	8	390	NA
Silver	mg/kg	0.19 J	0.17 J	0.12 GJ	0.16 GJ	0.22 GJ	NA	400	8	390	NA
Thallium	mg/kg	ND	ND	ND G	ND G	ND G	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	158	85.1	56.8 G	40.0 G	48.7 G	NA	24,000	480	23,000	86
Mercury	mg/kg	0.031 J	0.042 J	0.035 J	0.032 J	ND	1	24	24	7.8[f]/23[g]	0.07

Notes:

This table includes only those constituents detected in the samples.

Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes and acronyms.

TABLE 6-9
GREASE PITS, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration					Regulatory/Risk-Based Criteria				Background
		GP-SB02-01	GP-SB02-02	GP-SB03-01	GP-SB06-01	GP-SB03-02	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
					(dup SB03-01)						
Sample Date		8/4/1998	8/4/1998	8/3/1998	8/3/1998	8/3/1998					
Sample Depth	ft bgs	3.5	6.0	3.0	3.0	5.0					
TPH											
Unknown hydrocarbon	mg/kg	ND	ND	82 YJ	ND	ND	100/200	NA	NA	NA	
VOCs	mg/kg	ND	ND	ND	ND	ND					
SVOCs											
Diethyl phthalate	mg/kg	0.081 J	ND	ND	ND	0.058 J	NA	64,000	1,280	63,000	
PCBs/Pesticides											
gamma-BHC (Lindane)	mg/kg	ND	2.0	ND	ND	ND	1,000	769	6.73	490	
Metals											
Antimony	mg/kg	0.066 J	0.071 J	0.068 J	0.088 J	0.069 J	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**2.5**	**1.6**	**3.1**	**3.5**	**7.9**	20	1.67	0.005	0.43	7
Barium	mg/kg	**369**	**374**	95.5	96.4	**232**	NA	5,600	112	5,500	257
Beryllium	mg/kg	**1.2**	**1**	**0.72 J**	**1.2**	**0.9 J**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	0.055 J	0.025 J	0.030 J	0.031 J	0.028 J	2	80	1.6	39	1
Chromium	mg/kg	**24.0 B**	**19.5 B**	**19.0 BJ**	**24.2 B**	**19.5 BJ**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	**133**	**103**	45.0 J	42.3	**92.3 J**	NA	2,960	59.2	3,100	114
Lead	mg/kg	16.5	5.8	24.4 J	13.4	17 J	250	NA	NA	400[d]	17
Nickel	mg/kg	19.9	16.1	6.2	7.4	15.0	NA	1,600	32	1,600	38
Selenium	mg/kg	ND	ND	0.17 J	0.34 J	0.12 J	NA	400	8	390	NA
Silver	mg/kg	0.24 J	0.17 J	0.13 J	0.15 J	0.18 J	NA	400	8	390	NA
Thallium	mg/kg	0.11 J	ND	**0.28 J**	**0.16 J**	**0.18 J**	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	78.1	65.6	32.0 J	36.8	61.6 J	NA	24,000	480	23,000	86
Mercury	mg/kg	ND	ND	ND	ND	ND	1	24	24	7.8[f]/23[g]	0.07

Notes:

This table includes only those constituents detected in the samples.

Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes and acronyms.

TABLE 6-10
PESTICIDE MIXING/STORAGE BUILDING, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration												Regulatory/Risk-Based Criteria				Background
		PM-SS01-01	PM-SS02-01	PM-SB01-01	PM-SB01-02	PM-SB01-03	PM-SB02-01	PM-SB02-02	PM-SB02-03	PM-SB03-01	PM-SB03-02	PM-SB03-03	PM-SB04-02	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
													(dup SB03-02)					
Sample Date		7/22/1998	7/22/1998	7/21/1998	7/21/1998	7/21/1998	7/22/1998	7/22/1998	7/22/1998	7/22/1998	7/22/1998	7/22/1998	7/22/1998					
Sample Depth	ft bgs	0.0	0.0	0.0	7.5	15.0	0.0	7.5	12.5	1.0	3.0	5.5	3.0					
TPH																		
Unknown Hydrocarbons	mg/kg	**180 JY**	**220 JY**	34 JY	ND	19 JY	98 JY	ND	ND	18 JY	21 JY	14 JY1	ND	200	NA	NA	NA	
VOCs	mg/kg	NA	NA	NA			NA											
Acetone	mg/kg				ND	0.026 J		ND	0.044	ND	ND	ND	ND	NA	8,000	80	7,800	
Carbon disulfide	mg/kg				ND	ND		ND	0.013	ND	ND	ND	ND	NA	8,000	80	7,800	
SVOCs																		
Hexachlorobenzene	mg/kg	ND	**0.19 J**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	0.625	0.00547	0.4	
Di-n-butyl phthalate	mg/kg	ND	0.19 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	8,000	160	7,800	
Bis (2-ethylhexyl) phthalate	mg/kg	0.14 J	0.18 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	71.4	0.625	46	
Butyl benzyl phthalate	mg/kg	ND	ND	ND	ND	ND	0.10 J	ND	ND	ND	ND	ND	ND	NA	16,000	320	16,000	
PCBs/Pesticides																		
4,4'-DDE	µg/kg	9.8	**44**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	2,940	25.7	1,900	
4,4'-DDD	µg/kg	21	22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	4,170	36.5	2,700	
4,4'-DDT	µg/kg	16	**77**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,000	2,940	25.7	1,900	
Organophos. Pesticides	µg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
Chlor. Herbicides																		
2,4-D	µg/kg	81 GJ	ND G	ND G	ND	ND	ND G	ND	ND	ND G	ND	ND	ND	NA	NA	NA	NA	
2,4,5-T	µg/kg	11 J	26 J	ND G	ND	ND	ND G	ND	ND	ND G	ND	ND	ND	NA	NA	NA	NA	
Metals																		
Antimony	mg/kg	0.54 GJ	0.48 GJ	0.15 GJ	0.087 GJ	ND G	0.062 GJ	0.065 GJ	ND	0.060 GJ	0.079 GJ	0.056 GJ	0.11 GJ	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**6.7 G**	**10.1 G**	**2.9 G**	**4.8 G**	**3.8 G**	**2.0 G**	**4.2 G**	**1.4 G**	**2.4 G**	**3.0 G**	**3.6 G**	**3.3 G**	20	1.67	0.005	0.43	7
Barium	mg/kg	**156 G**	**136 G**	**163 G**	86.9 G	**242 G**	**204 G**	**125 G**	**216 G**	**213 G**	111 G	**155 G**	**121 G**	NA	5,600	112	5,500	257
Beryllium	mg/kg	**0.39 GJ**	**0.37 GJ**	**0.66 G**	**1.0 G**	**0.77 G**	**0.84 G**	**0.95 G**	**0.89 G**	**0.72 G**	**0.61 G**	**0.94 G**	**0.63 G**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	**2.2 G**	**2.0 G**	0.94 G	1.1 G	1.1 G	0.81 G	0.96 G	1.3 G	0.95 G	**2.7 G**	0.97 G	1.0 GJ	2	80	1.6	39	1
Chromium	mg/kg	**14.9 GB**	**15.0 GB**	**21.6 GB**	**20.0 GB**	**25.8 GB**	**25.8 GB**	**24.4 GB**	**28.9 GB**	**24.3 GB**	**22.8 GB**	**25.6 GB**	**24.2 GB**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	49.8 J	**77.3 GB**	**88.6 GB**	**123 GB**	**118 GB**	**74.1 GB**	**72.4 GB**	**166**	**86.8 GB**	**70.9 GB**	**102 GB**	**74.4**	NA	2,960	59.2	3,100	114
Lead	mg/kg	241 G	**295 G**	66.4 G	9.2 G	6.9 G	41.1 G	9.5 G	8.2 G	17.5 G	10.1 G	8.7 G	10.6 G	250	NA	NA	400[d]	17
Nickel	mg/kg	14.8 G	12.3 G	10.0 G	6.7 G	12.7 G	9.7 G	12.4 G	10.2 G	10.1 G	10.1 G	12.1 G	11.2 G	NA	1,600	32	1,600	38
Selenium	mg/kg	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	NA	400	8	390	NA
Silver	mg/kg	0.11 GJ	0.11 GJ	0.11 GJ	0.13 GJ	0.14 GJ	0.11 GJ	0.11 GJ	0.14 GJ	0.14 GJ	0.11 GJ	0.10 J	0.18 GJ	NA	400	8	390	NA
Thallium	mg/kg	ND G	ND G	**0.24 GJ**	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	180 GJ	350 G	72.4 G	43.6 G	61.6 G	67.2 G	57.4 G	71.9 G	169 G	55.6 G	48.8 G	55.2 G	NA	24,000	480	23,000	86
Mercury	mg/kg	0.023 JG	0.052 J	ND	ND	ND	0.039 J	ND	ND	ND	0.044	ND	0.042	1	24	24	7.8[f]/23[g]	0.07

Notes:

This table includes only those constituents detected in the samples.

Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes and acronyms.

TABLE 6-11
VARIOUS SITES, CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration						Regulatory/Risk-Based Criteria			
		Pesticide Building		Sewage Pond		Sump	Drilling				
		PM-MW01-01	PM-MW02-01	SP-MW01-01	SP-MW02-01	HM-SU01-01	DW-WR01-01	MCL	MTCA A	MTCA B	EPA Reg. 3
		Upgradient	Downgradient	Downgradient	Upgradient						
Sample Date		8/5/1998	8/5/1998	8/6/1998	8/5/1998	8/6/1998	8/5/1998				
TPH											
Unknown Hydrocarbons	mg/L	ND	ND	ND	ND	**51 YJ**	ND	NA	1	NA	NA
VOCs											
Bromoform	µg/L	ND	ND	ND	ND	ND	0.43 J	100/80	NA	5.54	2.4
Dibromochloromethane	µg/L	ND	ND	ND	ND	ND	**0.24 J**	100/80	NA	0.521	0.13
SVOCs											
bis(2-ethylhexyl)phthalate	µg/L	ND	ND	ND	ND	**52/10***	ND	6	NA	6.25	4.8
PCBs/Pesticides	µg/L	ND	ND	NA	NA	ND	ND				
Explosives	µg/L	NA	NA	NA	NA	ND	ND				
PETN	µg/L	NA	NA	NA	NA	NA	2.4 J	NA	NA	NA	NA
Picric Acid	µg/L	NA	NA	NA	NA	NA	ND				
Organophos. Pest.	µg/L	ND	ND	NA	NA	NA	ND				
Cl. Herbicides	µg/L	ND	ND	NA	NA	NA	ND				
Metals - Total											
Antimony	mg/L	ND	ND	ND	ND	**0.002**	ND	0.006	0.0014 - 0.008[a]	0.0014 - 0.008[a]	0.015
Arsenic	mg/L	ND	ND	ND	**0.0012 J**	**0.01**	**0.0054**	0.05	0.005	0.00005	0.000045
Barium	mg/L	0.19	0.079	0.0066	0.039	0.097	ND	2	1.12	1.12	2.6
Beryllium	mg/L	ND	ND	ND	ND	**0.00027 J**	ND	0.004	0.0000203	0.0000203	0.000016
Cadmium	mg/L	0.00017 J	ND	ND	ND	0.0021	ND	0.005	0.008	0.008	0.018
Chromium	mg/L	ND	ND	0.00099 J	0.0035	0.0096	ND	0.1	16[b] (0.08)[c]	16[b] (0.08)[c]	37[b] (0.18)[c]
Copper	mg/L	0.0035	0.00062	0.00033 J	0.0051	0.069 B	0.0014	1.3	0.592	0.592	1.5
Lead	mg/L	0.00081 J	0.0027	ND	0.00056 J	**0.12**	0.00028 J	0.015	NA	NA	0.015
Nickel	mg/L	0.0027	0.0015	0.00069 J	0.0032	0.0095	ND	0.1	0.32	0.32	0.73
Selenium	mg/L	0.00014 J	0.00020 J	0.00016 J	0.00016 J	0.0014 J	0.00016 J	0.05	0.08	0.08	0.18
Silver	mg/L	ND	ND	ND	ND	0.00013 J	ND	NA	0.08	0.08	0.018
Thallium	mg/L	0.00017 J	0.00010 J	ND	ND	ND	ND	0.002	0.00112	0.00112	0.0029-0.0033
Zinc	mg/L	0.029	0.012 J	0.0018 J	0.0056 J	**12.0 B**	0.013 J	NA	4.8	4.8	11
Mercury	mg/L	ND	ND	ND	ND	ND	ND	2	4.8	4.8	11[d]/3.7[e]

TABLE 6-11
VARIOUS SITES, CONSTITUENTS DETECTED IN GROUNDWATER SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration						Regulatory/Risk-Based Criteria			
		Pesticide Building		Sewage Pond		Sump	Drilling				
		PM-MW01-01	PM-MW02-01	SP-MW01-01	SP-MW02-01	HM-SU01-01	DW-WR01-01	MCL	MTCA A	MTCA B	EPA Reg. 3
Metals - Dissolved						NA	NA				
Antimony	mg/L	0.00022 J	0.00036 J	ND	0.00017 J			0.006	0.0014 - 0.008[a]	0.0014 - 0.008[a]	0.015
Arsenic	mg/L	ND	**0.00042 J**	ND	**0.0017 J**			0.05	0.005	0.00005	0.000045
Barium	mg/L	0.19	0.078	0.0082	0.031			2	1.12	1.12	2.6
Beryllium	mg/L	ND	ND	ND	ND			0.004	0.0000203	0.0000203	0.000016
Cadmium	mg/L	ND	ND	ND	ND			0.005	0.008	0.008	0.018
Chromium	mg/L	ND	ND	0.0012	0.00099 J			0.1	16 [b] (0.08)[c]	16 [b] (0.08)[c]	37[b] (0.18)[c]
Copper	mg/L	0.0066	0.0098	0.0040	0.0041			1.3	0.592	0.592	1.5
Lead	mg/L	0.0023	ND	ND	ND			0.015	NA	NA	0.015
Nickel	mg/L	0.0038	0.0022	0.0014	0.0030			0.1	0.32	0.32	0.73
Selenium	mg/L	0.00015 J	ND	ND	ND			0.05	0.08	0.08	0.18
Silver	mg/L	ND	ND	ND	ND			NA	0.08	0.08	0.018
Thallium	mg/L	0.00027 J	ND	ND	ND			0.002	0.00112	0.00112	0.0029-0.0033
Zinc	mg/L	0.018	0.014	0.0024 J	0.0053 J			NA	4.8	4.8	11
Mercury	mg/L	ND	ND	ND	ND			2	4.8	4.8	11[d]/3.7[e]
WQ Parameters											
Alkalinity, Total	mg/L	132	129	112	94.3	NA	73.5	NA	NA	NA	NA
Alk, Bicarb. as CaCO3	mg/L	132	129	112	94.3	NA	72.7	NA	NA	NA	NA
Alk, Carb. as CaCO3	mg/L	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA
Alk, Hydrox.. as CaCO3	mg/L	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA
Chloride	mg/L	2.6	1.8	1.3	1.6	NA	2.4	250	NA	NA	NA
Cyanide	mg/L	NA	NA	NA	NA	NA	ND	0.2	NA	0.32	0.18-7.3
Fluoride	mg/L	0.19	0.2	0.17	0.12	NA	ND	1.4 - 2.4	NA	0.96	2.2
Nitrate as N	mg/L	0.050 J	0.050 J	ND	ND	NA	0.060 J	10	NA	25.6	58
Orthophosphate as P	mg/L	ND	ND	ND	ND	NA	ND	NA	NA	NA	NA
Sulfate	mg/L	1.7	0.64 J	0.27 J	1.2	NA	0.64 J	250	NA	NA	NA
Total Suspended Solids	mg/L	ND	16.0	ND	10.0	NA	ND	NA	NA	NA	NA
Calcium	mg/L	33.4	24.9	20.9	18.2	NA	10.0	NA	NA	NA	NA
Iron	mg/L	0.67	1.2	0.13	8.1	NA	ND	NA	NA	NA	NA
Magnesium	mg/L	9.7	8.3	9.5	8.1	NA	0.22 J	NA	NA	NA	NA
Manganese	mg/L	0.65	0.39	0.86	1.2	NA	0.00085 J	NA	NA	2.24	1.7
Potassium	mg/L	3.9 J	1.3 J	0.77 J	1.5 J	NA	0.23 J	NA	NA	NA	NA
Sodium	mg/L	8.9	7.3	10.0	8.9	NA	20.3	NA	NA	NA	NA
Fecal Coliform	mg/L	NA	NA	2	8	NA	ND	NA	NA	NA	NA
Fecal Strep	mg/L	NA	NA	ND	4	NA	ND	NA	NA	NA	NA

Notes:

This table includes only those constituents detected in the samples.

Shading indicates that the value exceeds one or more regulatory criteria.

*Includes initial results and results on re-extraction and re-analyses.

See Table 6-17 for additional notes and acronyms.

TABLE 6-12
ABOVEGROUND STORAGE TANKS, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration									Regulatory/Risk-Based Criteria			
		ST-SS01-01	ST-SS02-01	ST-SS03-01	ST-SS04-01	ST-SS05-01	ST-SS05-02	ST-SS06-01	ST-SS07-01	ST-SS08-01	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3
							(dup SS05-01)							
Sample Date		3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998				
Sample Depth	ft bgs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
TPH														
Unknown Hydrocarbons	mg/kg	**8100 YJ**	**3900 YJ**	**9000 YJ**							200	NA	NA	NA
Diesel Fuel #2	mg/kg				**34000[1]**	**1200[1]**	**1100[1]**	**15000[1]**	**37000[1]**	**4600[1]**	200	NA	NA	NA

Notes:

This table includes only those constituents detected in the samples.

[1] = Suspected weathered diesel

Shading indicates that the value exceeds one or more regulatory criteria.

See Table 6-17 for additional notes and acronyms.

TABLE 6-13
FORMER SEWAGE POND, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration																	Regulatory/Risk-Based Criteria				Background
		SP-SB01-01	SP-SB01-02	SP-SB01-03	SP-SB02-01	SP-SB02-02	SP-SB02-03	SP-SB03-01	SP-SB07-01 (dup SB03-01)	SP-SB03-02	SP-SB03-03	SP-SB04-01	SP-SB06-01 (dup SB04-01)	SP-SB04-02	SP-SB-04-03	SP-SB05-01	SP-SB05-02	SP-SB05-03	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
Sample Date		7/17/1998	7/17/1998	7/17/1998	7/17/1998	7/17/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998	7/20/1998					
Sample Depth	ft bgs	4.0	5.0	9.5	4.5	5.0	12.5	3.5	3.5	9.0	12.0	4.0	4.0	7.5	10.0	4.0	10.0	12.5					
TPH	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	200	NA	NA	NA	
VOCs																							
Acetone	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0037 J	ND	ND	NA	ND	ND	NA	ND	NA	8,000	80	7,800	
Carbon disulfide	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	NA	0.0052 J	NA	8,000	80	7,800	
SVOCs	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
PCBs/Pesticides	µg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
Metals																							
Antimony	mg/kg	0.071 J	0.11 J	0.082 J	0.088 J	0.10 J	0.084 GJ	0.074 GJ	0.056 GJ	0.24 GJ	0.17 GJ	0.13 GJ	0.17 GJ	0.084 GJ	ND G	0.18 GJ	0.14 GJ	0.067 GJ	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**3.6**	**4.5**	**4.4**	**3.4**	**4.0**	**4.0 G**	**3.9 G**	**3.9 G**	**7.2 G**	**6.2 G**	**4.9 G**	**6.3 G**	**3.1 G**	**3.5 G**	**6.4 G**	**3.2 G**	**3.4 G**	20	1.67	0.005	0.43	7
Beryllium	mg/kg	**0.86**	**0.84**	**0.57**	**0.93**	**0.86**	**0.52 G**	**0.92 G**	**1.0 G**	**0.81 G**	**1.1 G**	**0.91 G**	**1.1 G**	**0.70 G**	**0.47 GJ**	**0.88 G**	**0.77 G**	**0.82 G**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	0.11 J	0.041 J	0.071 J	0.073 J	0.059 J	1.0 G	1.2 G	1.2 G	1.3 G	0.99 G	1.0 G	1.2 G	1.1 G	0.62 G	1.2 G	1.1 G	1.5 G	2	80	1.6	39	1
Chromium	mg/kg	**22.0**	**27.0**	**22.0**	**31.4**	**23.9**	**18.2 G**	**27.5 G**	**25.5 G**	**26.3 G**	**27.3 G**	**26.2 G**	**28.3 G**	**24.3 G**	**11.5 G**	**25.9 G**	**26.1 G**	**28.7 G**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	**60.5**	56.6	**77.3**	**89.7**	**67.8**	**79.5 GB**	**60.4 GB**	54.6 GB	31.9 GB	**110 G**	**61.4 J**	**71.7 GB**	**84.3 GB**	**68.4 G**	48.4 GB	44.1 GB	**123 GB**	NA	2,960	59.2	3,100	114
Lead	mg/kg	13.2	11.0	6.6	9.2	9.4	4.2 G	9.2 G	9.0 G	12.5 G	8.3 G	7.9 G	9.0 G	7.7 G	3.0 G	8.4 G	10.3 G	6.7 G	250	NA	NA	400[d]	17
Nickel	mg/kg	11.9	15.8	13.0	11.1	12.3	11.3 G	14.4 G	12.4 G	20.5 G	23.3 G	13.7 G	14.9 G	13.1 G	7.8 G	18.0 G	17.8 G	11.7 G	NA	1,600	32	1,600	38
Selenium	mg/kg	ND	ND	ND	ND	ND	ND G	ND	0.13 GJ	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	ND G	NA	400	8	390	NA
Silver	mg/kg	0.17 J	0.17 J	0.21 J	0.20 J	0.18 J	0.21 GJ	0.19 GJ	0.19 GJ	0.32 GJ	0.16 GJ	0.19 GJ	0.21 GJ	0.24 GJ	0.085 GJ	0.25 GJ	0.29 GJ	0.26 GJ	NA	400	8	390	NA
Thallium	mg/kg	**0.12 J**	**0.19 J**	0.097 J	**0.21 J**	ND	ND G	ND G	ND G	ND G	**0.36 GJ**	ND G	ND G	ND G	ND G	ND G	ND G	ND G	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	67.8 B	56.6 B	56.2 B	53.9 B	44.7 B	49.7 G	60.9 G	59.0 G	70.1 G	73.4 G	43.8 J	52.0 G	65.7 G	39.0 G	52.5 G	65.7 G	80.2 G	NA	24,000	480	23,000	86
Mercury	mg/kg	0.038 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.037 J	ND	ND	1	24	24	7.8[f]/23[g]	0.07

Notes:
This table includes only those constituents detected in the samples.
Concentrations in **bold** exceed one or more regulatory criteria but are below background.
Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).
See Table 6-17 for additional notes and acronyms.

TABLE 6-14
AMMUNITION STORAGE MAGAZINES, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

		Sample Concentration																												
		Surface Soil Grid Samples																		Subsurface Soils		Magazine Soils		Wipe Samples [a]				Regulatory/Risk Based Criteria				
Parameter	Units	AS-SS01-01	AS-SS01-02	AS-SS-02-01	AS-SS03-01	AS-SS04-01	AS-SS05-01	AS-SS06-01	AS-SS07-01	AS-SS08-01	AS-SS08-02	AS-SS09-01	AS-SS10-01	AS-SS11-01	AS-SS12-01	AS-SS13-01	AS-SS14-01	AS-SS15-01	AS-SB01-01	AS-SB01-02	AS-MG01-01	AS-MG02-01	AS-WP01-01	AS-WP02-01	AS-WP02-02	AS-WP03-01	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	Background
			(dup 01-01)								(dup 08-01)													(dup WP02-01)						
Sample Date		3/3/1998	3/3/1998	3/3/1998	3/3/1998	3/3/1998	3/3/1998	3/3/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	8/4/1998	8/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	3/4/1998	8/4/1998					
Sample Depth	ft bgs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	6.0	NA	NA	NA	NA	NA	NA					
Explosives																														
2,4,6-trinitrotoluene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.12 J	ND	ND	ND	ND	NA	33.3	0.292	21	
2,4-dinitrotoluene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.28 J	ND	ND	ND	ND	NA	160	3.2	160	
2-amino-4,6-dinitrotoluene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.28 J	ND	ND	ND	ND	NA	NA	NA	NA	
4-amino-2,6-dinitrotoluene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.53 J	ND	ND	ND	ND	NA	NA	NA	NA	
Hexahydro-1,3,5… (RDX)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**410 D**	ND	1.9 J	ND	ND	NA	9.09	0.08	NA	
Octahydro-1,3,5… (HMX)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.18 J	ND	ND	ND	ND	NA	NA	NA	NA	
PETN	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.4	ND	ND	ND	ND	NA	NA	NA	NA	
PA	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND R	ND R	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	
Metals																														
Antimony	mg/kg	0.26 J	0.35 J	0.48 J	0.36 J	0.32 J	0.52 J	0.42 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.074 J	0.089 J	**9.3**	**1.1 J**	4.4	ND	ND	0.60	NA	32 - 72[c]	0.64 - 1.44[c]	31	0.12
Arsenic	mg/kg	**10.9**	**9.0**	**10.0**	**8.6**	**4.2**	**9.6**	**7.7**	**10.3**	**14.1**	**13.6**	**15.5**	**7.8**	**9.2**	**11.7**	**8.3**	**9.3**	**11.2**	**4.1 J**	**4.7**	**11.7**	**9.0**	6.3	3.5	4.5	0.62	20	1.67	0.005	0.43	7
Barium	mg/kg	**238**	**190**	**406**	**407**	**278**	**573**	**432**	**451**	**551**	**497**	**741**	**2590**	**680**	**965**	**583**	**639**	**619**	**127**	**170**	82.8	**157**	61.4	42.3	51.8	7.0	NA	5,600	112	5,500	257
Beryllium	mg/kg	**1.6**	**1.5**	**1.8**	**1.5**	**1.3**	**2.3**	**1.7**	**2.0**	**2.6**	**2.4**	**3.9**	**4.8**	**2.6**	**5.6**	**2.4**	**2.0**	**2.5**	**0.7**	**0.8**	ND	**0.67**	ND	0.31	0.32	0.017 J	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	**3.1**	**2.4**	**2.5**	**2.3**	**1.9**	**2.5**	**1.9**	**2.6**	**4.5**	**3.4**	**3.6**	**18.0**	**5.3**	**18.3**	**2.6**	**2.3**	**2.5**	0.91	0.038 J	**3.7**	**9.8**	2.4	2.7	3.0	0.29	2	80	1.6	39	1
Chromium	mg/kg	**57.3**	**47.7**	**58.7**	**58.7**	**29.2**	**75.2**	**56.1**	**71.3**	**84.5**	**82.4**	**114**	**87.0**	**63.0**	**83.1**	**65.3**	**62.5**	**72.0**	**27.4 B**	**22.1 B**	**89.2**	**80.2**	63.1	17.3	20.0	2.7	100	80,000d/400[f]	1,600d/8e	78,000d/390e	42
Copper	mg/kg	**151**	**120**	**154**	**146**	**178**	**211**	**157 J**	**179**	**211**	**197**	**297**	**159**	**172**	**203**	**166**	**166**	**203**	**64.7**	**79.0**	**136**	**112**	94.8	82.9 J	53.1 J	5.6 B	NA	2,960	59.2	3,100	114
Lead	mg/kg	69.2 J	37.7 J	40.8	47.8	54.7	50.0	33.7	31.3	55.9	51.4	54.8	37.8	32.8	36.3	34.2	50.5	43.9	11.3	10.7	**566**	**386**	395	1170 J	263 J	9.4	250	NA	NA	400f	17
Nickel	mg/kg	**34.7**	29.4	**34.3**	**35.7**	28.9	**41.5**	**32.6**	**35.2**	**56.6**	**42.2**	**58.2**	**117**	**52.1**	**98.3**	**35.1**	**38.7**	**44.7**	14.1	14.4	19.8	24.6	8.5	7.5	7.5	0.98	NA	1,600	32	1,600	38
Selenium	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	400	8	390	NA
Silver	mg/kg	0.41 J	0.49 J	0.55 J	0.45 J	0.34 J	0.49 J	0.44 J	ND	0.79 J	0.61 J	0.77 J	2.9 J	0.96 J	2.8 J	0.52 J	0.47 J	0.50 J	0.19 J	0.19 J	0.26 J	0.83	ND	ND	ND	0.017 J	NA	400	8	390	NA
Thallium	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	**0.49 J**	ND	ND	ND	ND	ND	ND	ND	ND	**0.33**	**0.23 J**	ND	ND	ND	ND	ND	ND	NA	5.6	0.112	6.3 - 7g	0.27
Zinc	mg/kg	129	95.1	147	171	151	258	178 J	160	267	282	307	**525**	246	**483**	192	220	210	44.8	44.9	399	436	212	191	215	35.4	NA	24,000	480	23,000	86
Mercury	mg/kg	0.26 J	0.17 J	0.16 J	0.16 J	0.087 J	0.18 J	0.12 J	0.21 J	0.20 J	0.20 J	0.28 J	0.058 J	0.13 J	0.067 J	0.14 J	0.20 J	0.15 J	ND	ND	**4.2**	0.27 J	1.6 J	0.065 J	0.11 J	ND	1	24	24	7.8h/23i	0.07

Notes:
This table includes only those constituents detected in the samples.
Concentrations in **bold** exceed one or more regulatory criteria but are below background.
Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).
See Table 6-17 for additional notes and acronyms.

TABLE 6-15
HAZARDOUS MATERIAL ACCUMULATION POINT, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration			Regulatory/Risk-Based Criteria				Background
		HM-SS-01-01	HM-SS-01-02	HM-SS-02-01	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
			(dup of SS01-01)						
Sample Date		2/27/1998	2/27/1998	2/27/1998					
Sample Depth	ft bgs	0.0	0.0	0.0					
TPH	mg/kg	15 JY	20 JY	ND	200	NA	NA	NA	
SVOCs									
bis (2-ethylhexyl) -phthalate	mg/kg	ND	0.033 J	ND	NA	71.4	0.625	46	
PCBs/Pesticides	mg/kg	ND	ND	ND					
Metals									
Antimony	mg/kg	0.054 J	0.043 J	0.062 J	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**0.53**	**0.63**	**0.96**	20	1.67	0.005	0.43	7
Barium	mg/kg	91.8	73.5	64.2	NA	5,600	112	5,500	257
Beryllium	mg/kg	**0.36**	**0.32**	**0.3**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	1.3	1	1.1	2	80	1.6	39	1
Chromium	mg/kg	6.1	5.9	5.5	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	48.5 J	22 J	19.6	NA	2,960	59.2	3,100	114
Lead	mg/kg	12.4 J	7.3 J	4	250	NA	NA	400[d]	17
Nickel	mg/kg	7	6.8	13.7	NA	1,600	32	1,600	38
Selenium	mg/kg	ND	ND	ND	NA	400	8	390	NA
Silver	mg/kg	0.21 J	0.17 J	0.16 J	NA	400	8	390	NA
Thallium	mg/kg	ND	ND	ND	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	51.5	41	44.2	NA	24,000	480	23,000	86
Mercury	mg/kg	ND	ND	ND	1	24	24	7.8[f]/23[g]	0.07

Notes:

This table includes only those constituents detected in the samples.

Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes and acronyms.

TABLE 6-16
FORMER CS TRAINING BUILDING, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration											Regulatory/Risk-Based Criteria			
		CS-SB01-01	CS-SB01-02	CS-SB02-01	CS-SB02-02	CS-SB03-01	CS-SB03-02	CS-SB04-01	CS-SB04-02	CS-SB05-01	CS-SB05-02	CS-SB06-02	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3
												(dup SB05-02)				
Sample Date		7/13/1998	7/13/1998	7/13/1998	7/13/1998	7/13/1998	7/13/1998	7/14/1998	7/14/1998	7/14/1998	7/14/1998	7/14/1998				
Sample Depth	ft bgs	0.1	2.0	0.2	2.0	0.2	2.0	0.2	2.0	0.1	2.0	2.0				
CS	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
SVOCs	mg/kg		NA		NA		NA		NA	NA						
2,4-Dinitrotoluene	mg/kg	ND		ND		0.70		ND			ND	ND	NA	160	3.2	160
2,6-Dinitrotoluene	mg/kg	ND		ND		0.051 J		ND			ND	ND	NA	80	1.6	78
Benzo(b)fluoranthene	mg/kg	ND		ND		**0.055 J**		**0.051 J**			ND	ND	1	0.137	0.0012	0.88
Bis(2-ethylhexyl)phthalate	mg/kg	ND		ND		0.063 J		0.046 J			ND	ND	NA	71.4	0.625	46
di-n-Butylphthalate	mg/kg	ND		ND		ND		ND			ND	0.17 J	NA	8,000	160	7,800
N-nitrosodiphenylamine	mg/kg	0.092 J		ND		0.50		ND			ND	ND	NA	204	1.79	130
Pyrene	mg/kg	ND		ND		ND		ND			0.066 J	ND	NA	2,400	48	2,300
Lead	mg/kg	83.9	NA	12.3	NA	**674**	NA	**278**	NA	NA	116	121	250	NA	NA	400[a]
Cyanide	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	1,600	32	1,600 - 16,000[b]

Notes:

This table includes only those constituents detected in the samples.

Shading indicates that the value exceeds one or more regulatory criteria and background (if applicable).

See Table 6-17 for additional notes and acronyms.

TABLE 6-17
WASH RACK NO.2, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

Parameter	Units	Sample Concentration					Regulatory/Risk-Based Criteria				Background
		W2-SB01-01	W2-SB01-02	W2-SB02-01	W2-SB03-01	W2-SB02-02	MTCA A	MTCA B	MTCA B-GW	EPA Reg. 3	
					(dup 02-01)						
Sample Date		7/27/1998	7/27/1998	7/27/1998	7/27/1998	7/27/1998					
Sample Depth	ft bgs	0.0	2.0	0.0	0.0	2.0					
TPH											
Unknown Hydrocarbons	mg/kg	8.2 JY	9.0 JY	22 JY	18 JY	9.5 JY	100/200	NA	NA	NA	
SVOCs	mg/kg	ND	ND	ND	ND	ND					
Metals											
Antimony	mg/kg	0.036 GJ	0.088 GJ	0.053 GJ	0.058 GJ	0.041 GJ	NA	32 - 72[a]	0.64 - 1.44[a]	31	0.12
Arsenic	mg/kg	**1.1 G**	**3.9 G**	**2.8 G**	**3.4 G**	**0.87 G**	20	1.67	0.005	0.43	7
Barium	mg/kg	**135 G**	**137 G**	**120 G**	**143 G**	100 G	NA	5,600	112	5,500	257
Beryllium	mg/kg	**0.46 G**	**0.62 G**	**0.79 G**	**0.87 G**	**0.44 G**	NA	0.233	0.002	0.15	2
Cadmium	mg/kg	0.44 G	0.68 G	0.68 G	0.61 G	0.54 G	2	80	1.6	39	1
Chromium	mg/kg	**16.1 GB**	**15.0 GB**	**19.7 GB**	**22.6 GB**	**11.9 GB**	100	80,000[b]/400[c]	1,600[b]/8[c]	78,000[b]/390[c]	42
Copper	mg/kg	**65.6 G**	**68.1 G**	**76.0 G**	**82.0 G**	54.1 G	NA	2,960	59.2	3,100	114
Lead	mg/kg	5.9 G	10.1 G	10.9 G	12.8 G	6.9 G	250	NA	NA	400[d]	17
Nickel	mg/kg	8.6 G	9.7 G	7.2 G	7.6 G	6.4 G	NA	1,600	32	1,600	38
Selenium	mg/kg	ND G	ND G	ND G	ND G	ND G	NA	400	8	390	NA
Silver	mg/kg	0.088 GJ	0.097 GJ	0.13 GJ	0.13 GJ	0.059 GJ	NA	400	8	390	NA
Thallium	mg/kg	ND G	ND G	ND G	ND G	ND G	NA	5.6	0.112	6.3 - 7[e]	0.27
Zinc	mg/kg	34.4 G	66.5 G	40.5 G	43.0 G	49.0 G	NA	24,000	480	23,000	86
Mercury	mg/kg	ND	ND	0.030 J	0.028 J	ND	1	24	24	7.8[f]/23[g]	0.07

Notes for all Section 6 Tables:

This table includes only those constituents detected in the samples.

Appendix H includes all laboratory results.

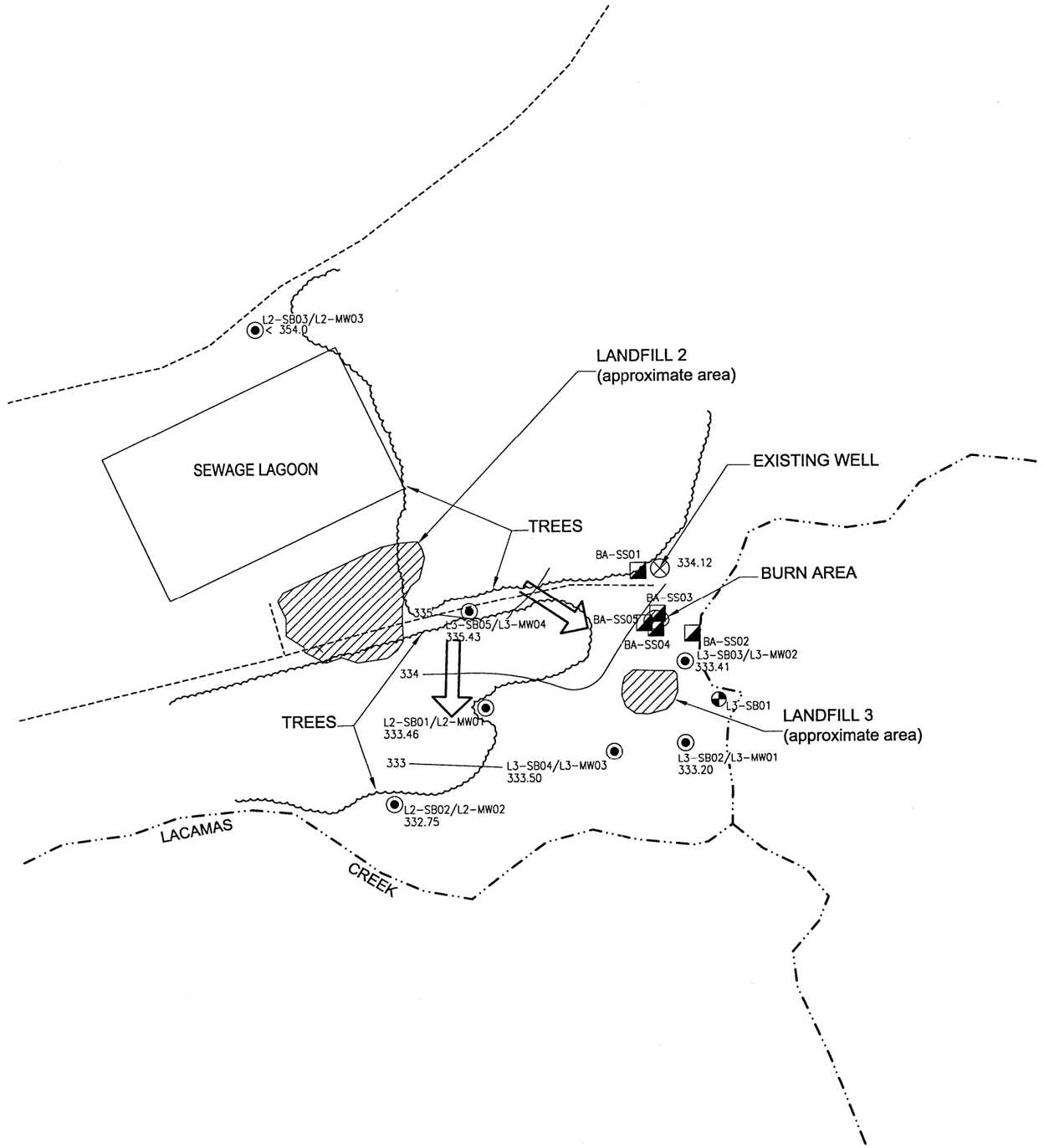
Concentrations in **bold** exceed one or more regulatory criteria but are below background.

Shading indicates that the level exceeds one or more regulatory criteria and background (if applicable).

µmhos/cm = micromhos per centimeter

TABLE 6-17
WASH RACK NO.2, CONSTITUENTS DETECTED IN SOIL SAMPLES
CAMP BONNEVILLE, VANCOUVER, WASHINGTON

NTU = Nephelometric turbidity units
ft bgs = feet below ground surface (top of sample interval)
µg/kg = micrograms per kilogram
µg/L = micrograms per liter
mg/L = milligrams per liter
mg/kg = milligrams per kilogram
EPA Reg. 3 = U.S. Environmental Protection Agency, Region 3, risk-based concentration (residential exposure)
MTCA A = Washington State Model Toxics Control Act Method A criteria
MTCA B = Washington State Model Toxics Control Act Method B criteria
MTCA B-GW = Washington State Model Toxics Control Act Method B criteria for the protection of groundwater
ND = Not detected
NA = Not available
TOC = total organic carbon
a = varies with the form of antimony
b = chromium III
c = chromium VI
d = EPA Screening Level based on Integrated Exposure Uptake Biokinetic (IEUBk) model
e = varies with the form of thallium
f = methyl mercury
g = inorganic mercury
h = The criterion is for total chlordane.
B = Analyte was detected in method blank.
G = Reporting limit is raised because of matrix interference.
J = Result was detected below the reporting limit or is an estimated concentration.
R = Result was rejected because multiple QC specifications were not met and/or corrected.
Y = Chromatographic profile is not consistent with patterns exhibited by reference fuel standards. Quantitation of unknown hydrocarbons in sample is based on diesel fuel.
UJ = Analyte was not detected, and the reporting limit is an estimate.
TPH = total petroleum hydrocarbons
PA = picric acid
PCBs = polychlorinated biphenyls
PETN = pentaerythritol tetranitrate
SVOCs = semivolatile organic compounds
VOCs = volatile organic compounds



N

LEGEND

- GRAVEL ROAD
- CREEK
- L3-SB01 — SOIL BORING LOCATION AND DESIGNATION
- L3-SB02/L3-MW01 333.20 — BORING AND MONITORING WELL LOCATION, DESIGNATION AND GROUNDWATER ELEVATION (MEASURED 8-3-98)
- BA-SS1 — SURFACE SOIL SAMPLE LOCATION AND DESIGNATION
- 333 — GROUNDWATER ELEVATION CONTOUR AND APPROXIMATE DIRECTION OF GROUNDWATER FLOW

NOTE

THE GROUNDWATER LEVEL IN THE EXISTING WELL WAS MEASURED ON 8-6-98.

0 150 300

Scale in Feet

Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

LANDFILLS 2 & 3 AND BURN AREA EXPLORATION PLAN

July 1999 T-4110-05

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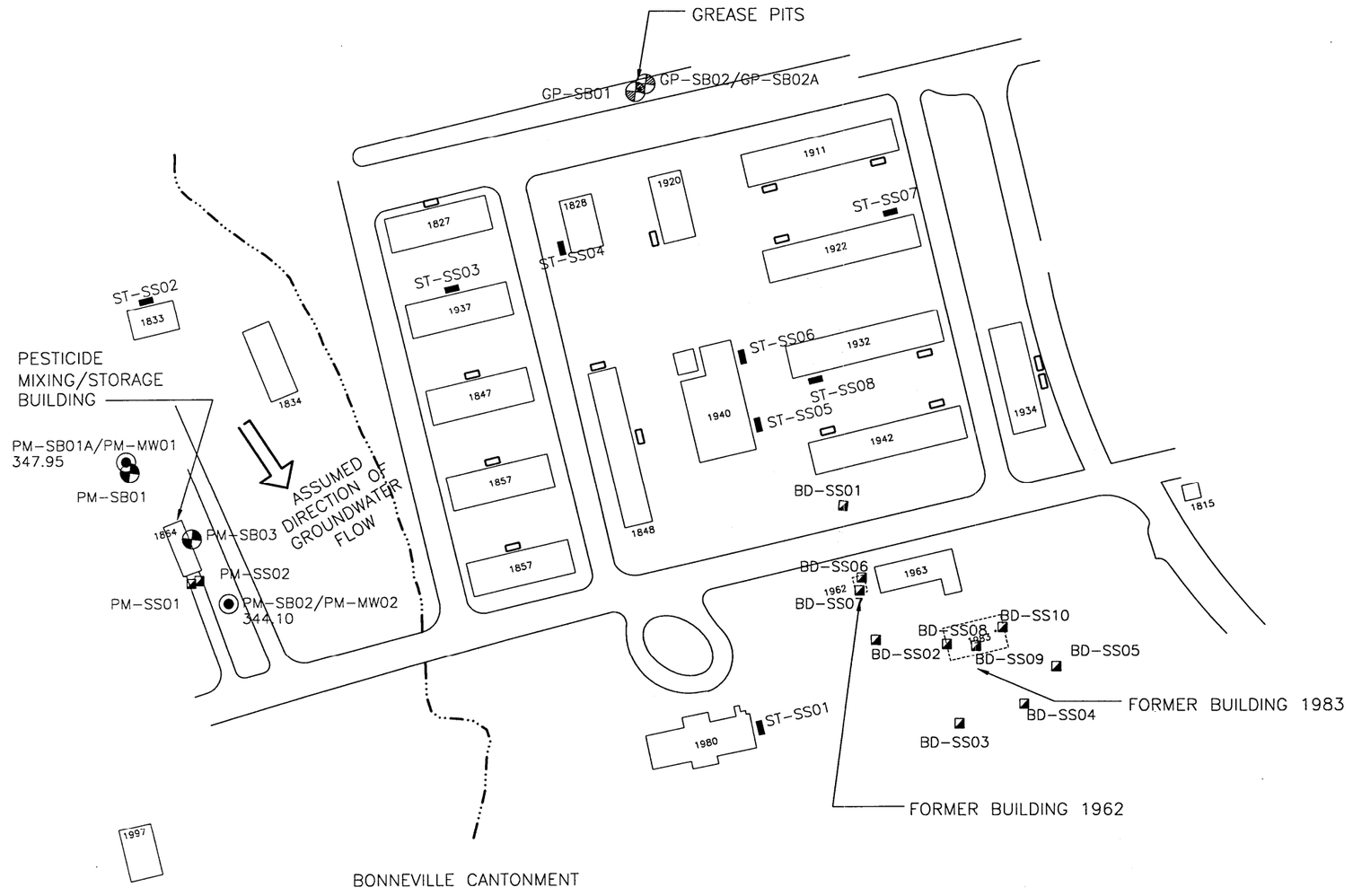
FIG. 6-1



N

LEGEND

- ABOVEGROUND STORAGE TANK
- ST-SS01 — ABOVEGROUND STORAGE TANK SAMPLE LOCATION AND DESIGNATION
- CREEK
- BD-SS01 — SURFACE SAMPLE LOCATION AND DESIGNATION
- PM-SB01 — SOIL BORING LOCATION AND DESIGNATION
- PM-SB1A/PM-MW01 347.95 — BORING AND MONITORING WELL LOCATION, DESIGNATION, AND GROUNDWATER ELEVATION (8-3-98)

NOTE

SAMPLE PREFIXES ARE AS FOLLOWS:

BD-XX00 = FORMER BUILDING 1962 AND 1983 SAMPLE

GP-XX00 = GREASE PIT SAMPLE

PM-XX00 = PESTICIDE MIXING/STORAGE BUILDING SAMPLE

ST-XX00 = ABOVEGROUND STORAGE TANK SAMPLE

Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

BONNEVILLE CANTONMENT AREA EXPLORATION PLAN

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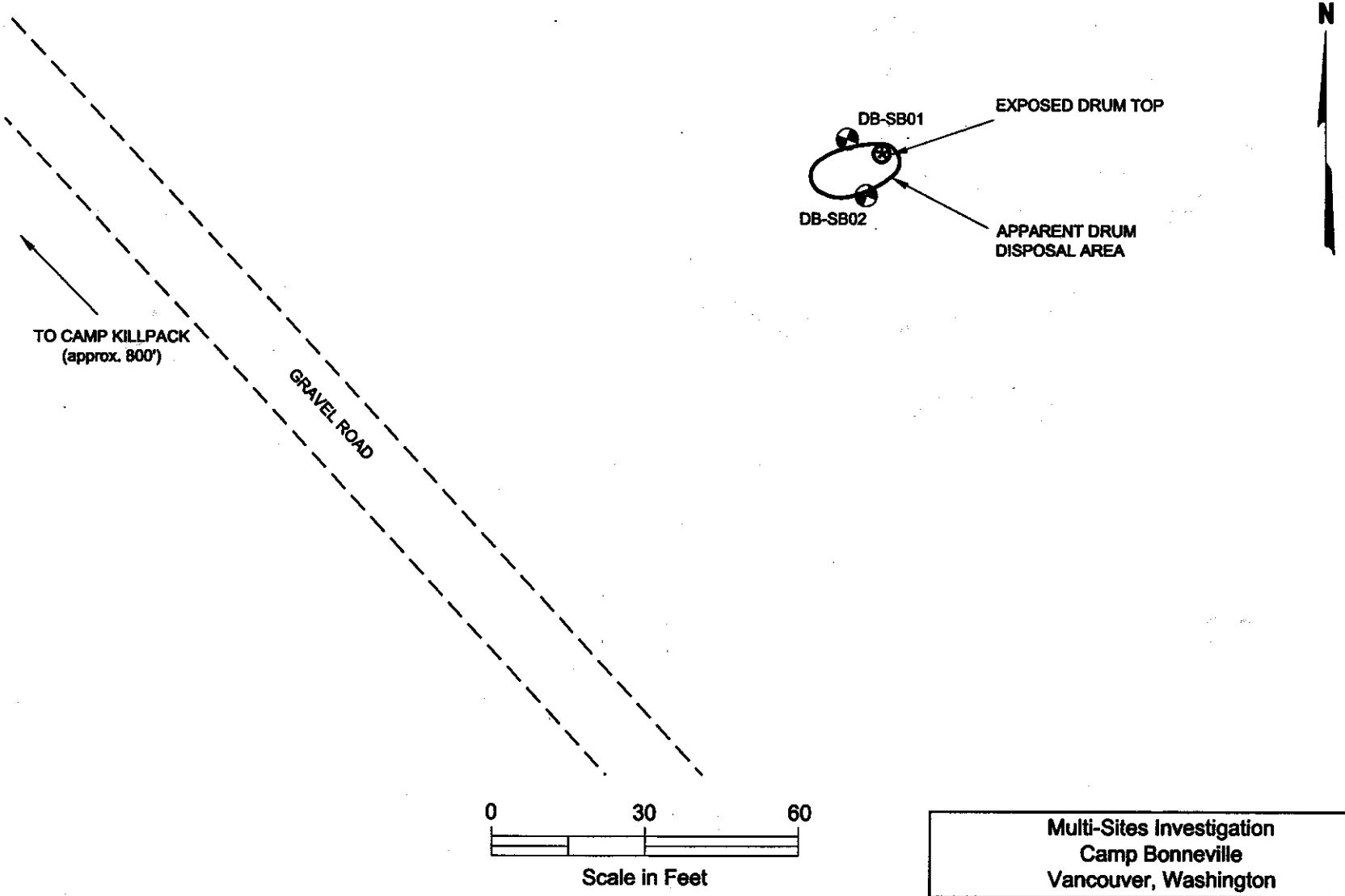
FIG. 6-2



LEGEND

DB-SB01 SOIL BORING LOCATION AND DESIGNATION

Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

DRUM DISPOSAL AREA EXPLORATION PLAN

July 1999 T-4110-05

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FIG. 6-3

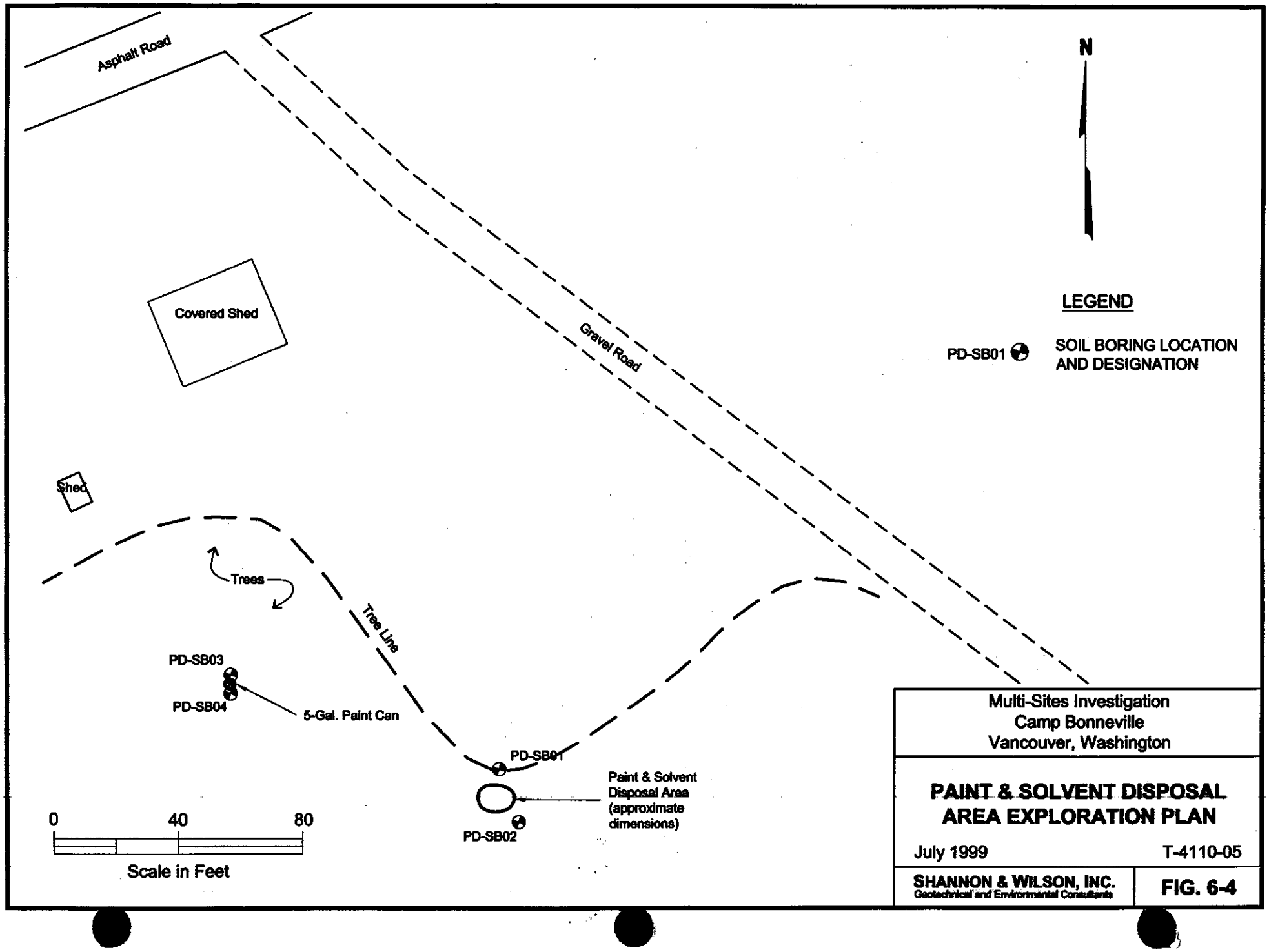
Asphalt Road
N
LEGEND
PD-SB01
SOIL BORING LOCATION AND DESIGNATION
Covered Shed
Gravel Road
Shed
Trees
Tree Line
PD-SB03
PD-SB04
5-Gal. Paint Can
PD-SB01
Paint & Solvent Disposal Area (approximate dimensions)
PD-SB02
0
40
80
Scale in Feet
Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington
PAINT & SOLVENT DISPOSAL AREA EXPLORATION PLAN
July 1999
T-4110-05
SHANNON & WILSON, INC.
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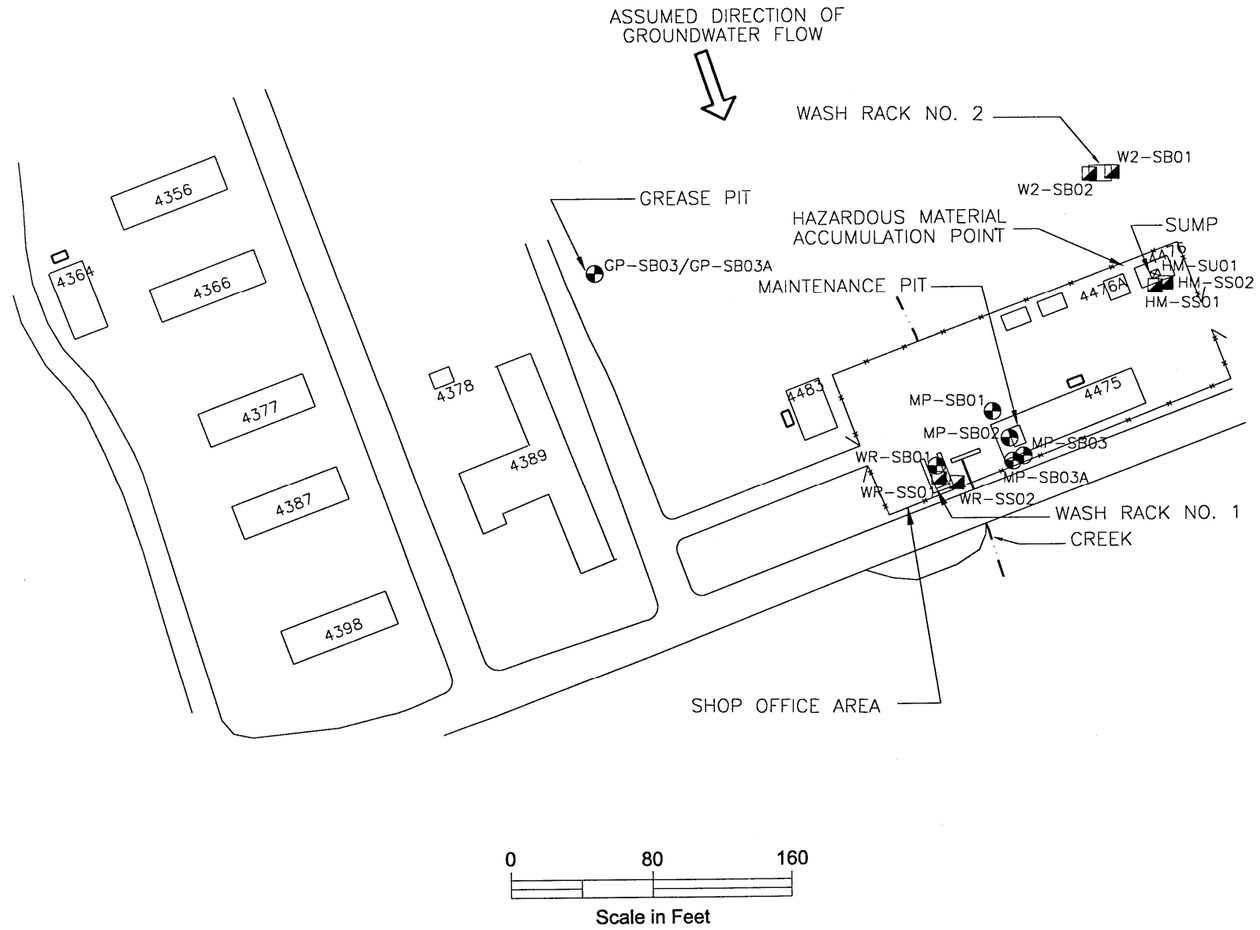
FIG. 6-4



N

LEGEND

- FENCE
- CREEK
- ABOVE GROUND STORAGE TANK
- MP-SB01 SOIL BORING LOCATION AND DESIGNATION
- HM-SS01 SURFACE/NEAR SURFACE SAMPLE LOCATION AND DESIGNATION
- HM-SU01 SUMP SAMPLE LOCATION AND DESIGNATION

Multi-Sites Investigation
Camp Bonneville
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KILLPACK CANTONMENT AREA EXPLORATION PLAN

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FIG. 6-5

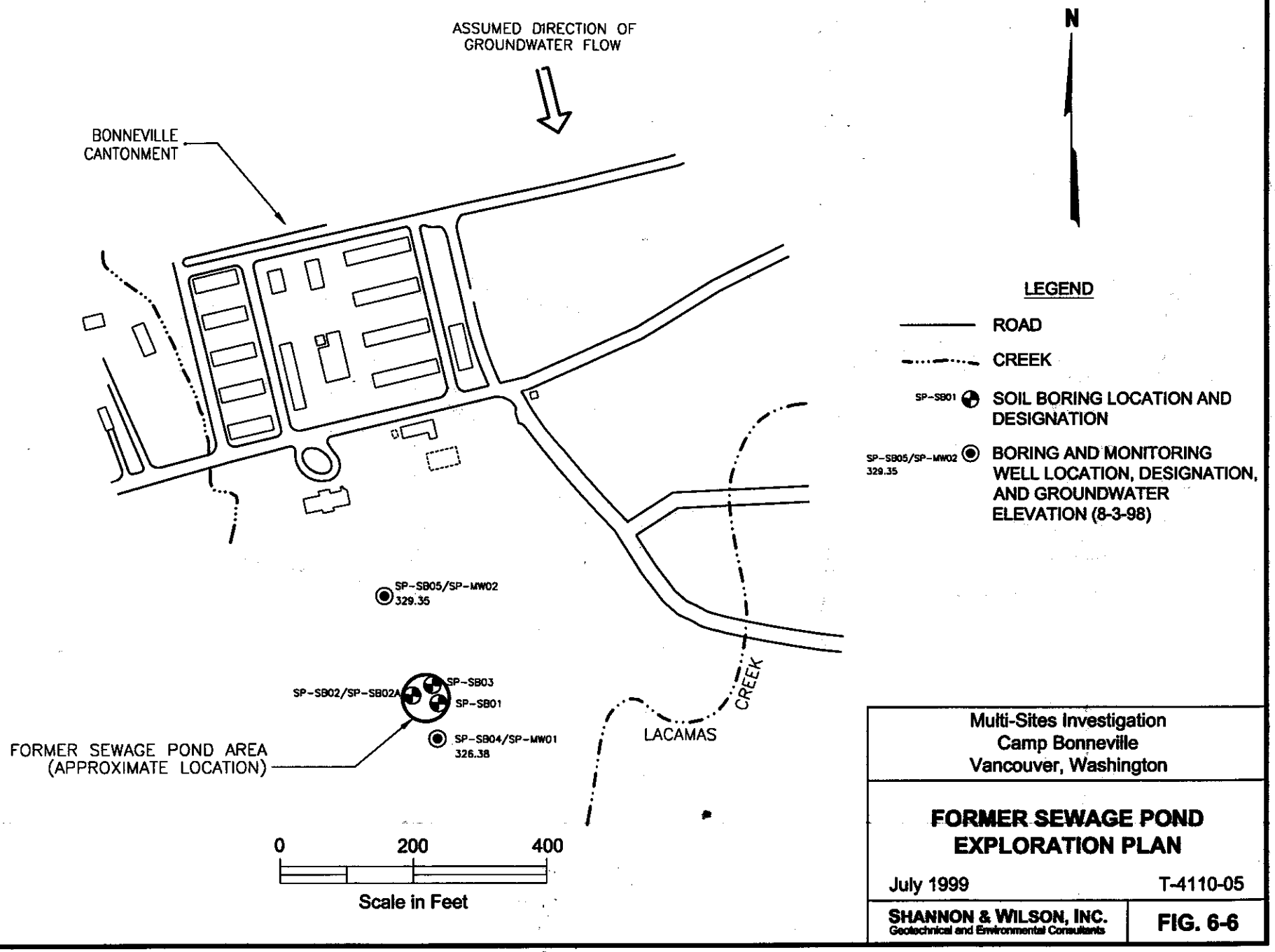
ASSUMED DIRECTION OF GROUNDWATER FLOW
BONNEVILLE CANTONMENT
SP-SB05/SP-MW02
329.35
SP-SB02/SP-SB02A
SP-SB03
SP-SB01
SP-SB04/SP-MW01
326.38
FORMER SEWAGE POND AREA (APPROXIMATE LOCATION)
LACAMAS CREEK
0
200
400
Scale in Feet
N
LEGEND
ROAD
CREEK
SP-SB01 SOIL BORING LOCATION AND DESIGNATION
SP-SB05/SP-MW02 329.35 BORING AND MONITORING WELL LOCATION, DESIGNATION, AND GROUNDWATER ELEVATION (8-3-98)
Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington
FORMER SEWAGE POND EXPLORATION PLAN
July 1999
T-4110-05
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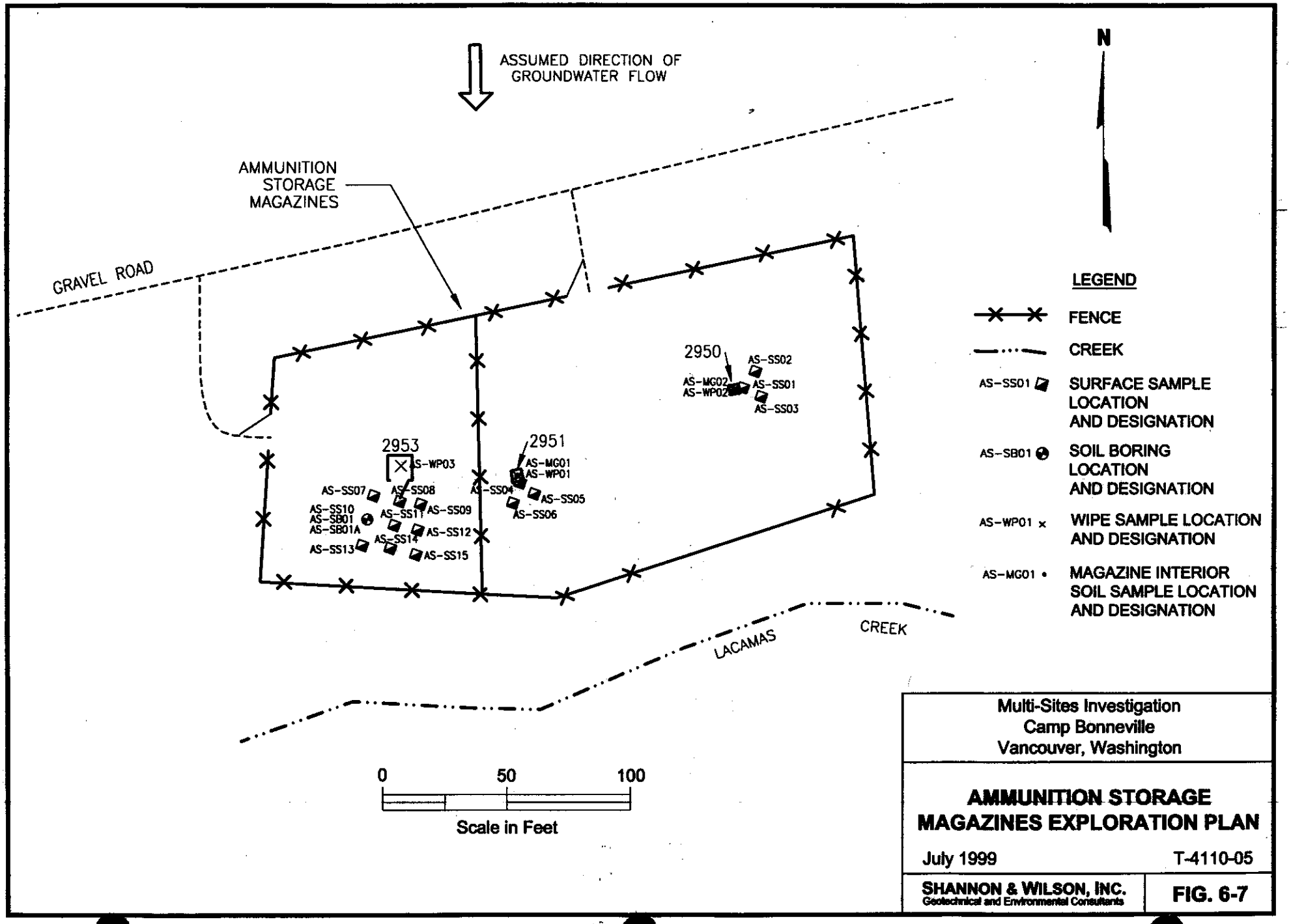
FIG. 6-6



Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

AMMUNITION STORAGE MAGAZINES EXPLORATION PLAN

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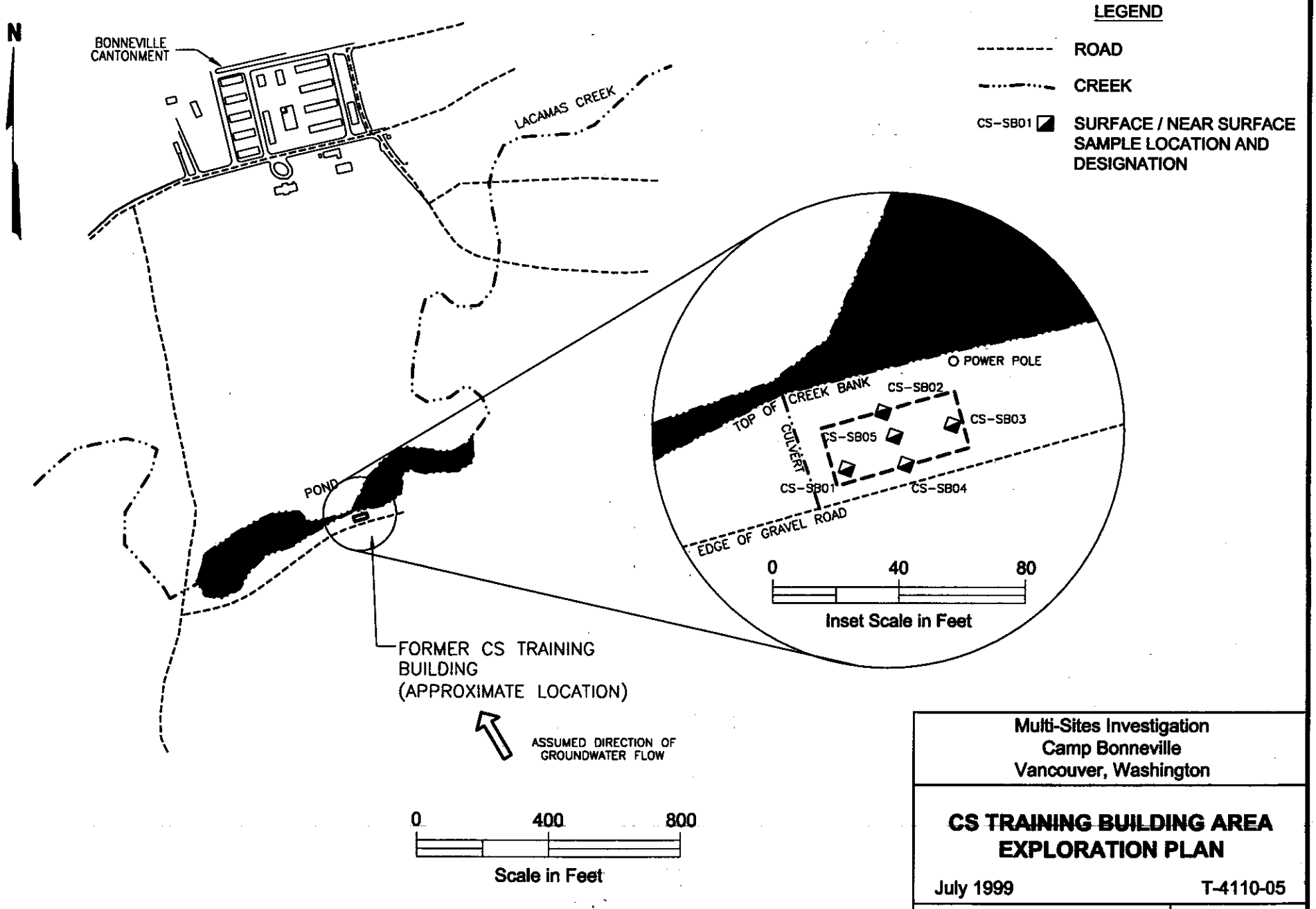
FIG. 6-7



Multi-Sites Investigation
Camp Bonneville
Vancouver, Washington

CS TRAINING BUILDING AREA EXPLORATION PLAN

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FIG. 6-8

7.0 CONCLUSIONS AND RECOMMENDATIONS

This field and laboratory investigation has been conducted to evaluate the potential for contamination resulting from past uses at 17 sites within Camp Bonneville. The investigation has been directed at evaluating potential environmental impacts from known or suspected activities at sites ranging from existing ASTs to alleged disposal areas. The primary objective of the investigation has been to determine whether each site poses a potential risk to human health or the environment, and to provide recommendations for further actions (where appropriate) for site remediation or for the performance of further investigations to better evaluate the need for and extent of remediation.

The sites can be grouped into those for which no further action is recommended, those for which remediation is recommended, and those for which additional investigation is recommended to better determine the extent of remediation that will be required for property transfer. A synopsis of the specific findings and recommendations for each site is provided in Table 7-1. Recommendations are described in more detail in the following paragraphs.

7.1 RECOMMENDATIONS FOR NO FURTHER ACTION

No further action (NFA) is recommended at the majority of the sites because either no evidence of contamination was detected or minimal contamination was detected. At most of these sites, constituents of concern either were not detected or were detected at concentrations below the project screening levels.

Normal background concentrations of several metals in soil exceeded one or more of the project screening levels, including arsenic, barium, beryllium, chromium, copper, and thallium. At some of the sites recommended for NFA, one or more of these metals were detected at concentrations only slightly exceeding the background level in a minimal number of samples. These slightly elevated concentrations may be representative of the normal variability of metals concentrations in soil. Although they exceed screening criteria, these constituents do not appear to pose a risk to human health and the environment, either because there is no exposure pathway under normal use scenarios, or because the constituents detected do not appear to be site specific. In addition, as described in WAC173-340-7407(e), in instances where only a single sample exceeds the background value but does not exceed two times the background value, and where less than 10 percent of the sample concentrations exceed the background value, the concentrations are considered to meet the cleanup level.

Arsenic was detected in one or more monitoring wells at each of the four sites where groundwater was sampled (Landfill 2, Landfill 3, Pesticide Mixing/Storage Building, and Former Sewage Pond). In one case (at the Former Sewage Pond site), arsenic was detected in the upgradient well but not in the downgradient well. Because the MDL and RL for arsenic in

groundwater exceed the MTCA Method B and EPA Region 3 screening criteria, all detected arsenic concentrations exceeded these criteria. However, none of the detected arsenic concentrations exceeded the MTCA Method A criterion or the MCL. No natural background concentration is available for arsenic in groundwater at Camp Bonneville. The natural background concentration for arsenic in soil exceeds the MTCA Method B groundwater protection, MTCA Method B, and EPA Region 3 criteria (but not MTCA Method A). Based on this, it appears that the detected concentrations of arsenic in groundwater may be due to natural conditions.

NFA is recommended at eleven of the sites:

- Landfill No 1 (existence could not be substantiated).
- Landfill No. 2.
- Landfill No. 3.
- Burn Area.
- Former Buildings 1962 and 1983.
- Paint and Solvent Disposal Area.
- Grease Pits (Camp Killpack and Camp Bonneville cantonments).
- 18 of 26 Aboveground Storage Tanks.
- Former Sewage Pond.
- Hazardous Material Accumulation Point.
- Wash Rack No. 2.

An NFA decision for the landfills should be contingent on the provision that future users would not build on or excavate into the area underlain by landfill debris.

7.2 RECOMMENDATIONS FOR REMEDIAL ACTIONS

Soil contamination that poses a potential risk to human health and the environment was identified at several sites. Sites at which remedial action is recommended include the following:

- Drum Disposal Area
- Wash Rack No. 1
- Pesticide Mixing/Storage Building
- Eight Aboveground Storage Tanks
- Ammunition Storage Magazines (magazine interiors)
- Former CS Training Building

Specific recommendations for remedial actions at these sites are provided in Table 7-1. At all of these sites, the soil contamination originated either at the ground surface or within a few feet of the surface, and does not appear to have migrated very far down into the soil column. Also, although the extent of contamination was not determined in this study, it is anticipated that for

most of the sites the shallow soil contamination does not extend far beyond the boundaries of the original source of contamination. Consequently, for most of these sites, the volume of soil that would require remediation appears to be relatively small. For example, in the case of the ASTs, the lateral extent of contamination is likely restricted to small areas directly beneath the tanks.

The contamination at the Ammunition Storage Magazines site includes both the magazines themselves and the surface soils in the vicinity of the magazines. Removal of debris and soil within the magazines and cleaning of the walls and floors is recommended to remediate the magazines. In contrast, the soil contamination at this site poses a larger environmental issue for which additional investigation is recommended (see Section 7.3).

For each of the other sites, the most effective means of remediation would likely be to excavate and properly dispose of the contaminated soil. Alternatively, it may be cost-effective to cap the contaminated soil if this approach is acceptable to risk managers and stakeholders.

7.3 RECOMMENDATIONS FOR ADDITIONAL INVESTIGATIONS

Further investigation is recommended at two of the sites:

- Maintenance Pit
- Ammunition Storage Magazines

In each case, additional site characterization is recommended to better define the extent of soil contamination and the potential for contaminant migration to groundwater and surface water.

7.3.1 Maintenance Pit

In the Maintenance Pit area, recommended explorations include surface soil sampling in front of the shop office (TPH and pesticide contamination) and behind the shop office (lead). Subsurface soil sampling is recommended behind the shop office (TPH and VOC contamination). In addition, the installation and sampling of groundwater monitoring wells and surface water and sediment sampling in the adjacent stream are recommended to evaluate the potential migration of TPH, VOCs, pesticides, and priority pollutant list (PPL) metals at the site. Additional investigation of the Maintenance Pit site should also address the potential for migration of contaminants from the adjacent Wash Rack No. 1 site (TPH and metals) to surface water and groundwater.

7.3.2 Ammunition Storage Magazines

At the Ammunition Storage Magazine site, recommended sampling includes the collection of surface and subsurface soil samples, surface water and sediment sampling, and installation and sampling of monitoring wells. Additional grid surface soil sampling is recommended to define the lateral extent of surface contamination. This information would aid in estimating the volume of soil that may require remediation at this site. Surface soil samples should be analyzed for PPL

metals plus barium. Additional soil sampling also is recommended directly in front of the large magazine, with both surface and subsurface samples collected to evaluate the potential for contaminant migration through soil and to groundwater. Recommended analyses in this location include priority pollutant metals (plus barium), explosives (including PETN and PA), SVOCs, and propellants.

Surface water and sediment sampling for PPL metals (plus barium) are recommended, both upstream and immediately downstream from the site in Lacamas Creek. Installation of upgradient and downgradient monitoring wells is recommended to evaluate the potential migration of highly mobile explosives compounds. Recommended analyses for soil samples from the borings and for groundwater samples include priority pollutant metals (plus barium), explosives (including PETN and PA), SVOCs, and propellants. Groundwater samples should also be analyzed for nitrate.

Because of analytical difficulties encountered with use of the PA method on soil samples, discussions on and modifications to the method should take place before sampling at this site. To date, several variations of the procedure have all met with difficulties.

TABLE 7-1
SUMMARY OF FINDINGS AND RECOMMENDATIONS

Site	Soil Results	Groundwater Results	Recommendations
Landfill No. 1	Landfill was not located by reconnaissance and geophysical methods.	Not sampled.	No further action is recommended. Previous evidence is interpreted to be indicative of a small debris pile associated with a former residence.
Landfill No. 2	Soil gas survey indicates no impact to air and no evidence of volatile organics in the landfill materials. Metals were the only constituents detected in downgradient borings, and none were at concentrations above the screening criteria and background.	Arsenic was detected in both wells sampled at concentrations exceeding risk-based criteria but below the MCL.	No further action is recommended. Arsenic concentrations in area wells are typically slightly elevated, and may be related to background conditions.
Landfill No. 3	Soil gas survey indicates no impact to air and no evidence of volatile organics in the landfill materials. Metals were the only constituents detected in downgradient borings, and none were at concentrations above the screening criteria and background.	Arsenic was detected in the downgradient wells at concentrations exceeding risk-based criteria but below the MCL.	No further action is recommended. Arsenic concentrations in area wells are typically slightly elevated, and may be related to background conditions.
Burn Area	Metals were the only constituents detected in downgradient borings, and only thallium was at a concentration above the screening criteria and background. Thallium was detected in one surface soil sample at a concentration slightly above background and the MTCA Method B groundwater protection criterion, but less than two times background.	Arsenic was detected in one nearby downgradient landfill well at a concentration exceeding risk-based criteria, but below the MCL.	No further action is recommended. Slightly elevated thallium, detected in one surface soil sample, may not exceed the actual natural concentration in site soils. The site does not appear to pose a threat to groundwater. Arsenic concentrations in area wells are typically slightly elevated, and may be related to background conditions.
Former Buildings 1962 and 1983	Only lead was detected in the surface and near-surface soil samples; concentrations detected did not exceed the screening criteria.	Not sampled.	No further action is recommended.

TABLE 7-1 (CONT.)
SUMMARY OF FINDINGS AND RECOMMENDATIONS

Site	Soil Results	Groundwater Results	Recommendations
Drum Disposal Area	TPH and several VOCs were detected at concentrations below screening levels. Antimony, barium, and copper were detected at concentrations exceeding background and MTCA Method B criteria for protection of groundwater.	Not sampled.	**Removal of drums and associated contaminated soil is recommended. Soil at the perimeter of the excavation should be screened for metals to verify removal of impacted soil.**
Paint and Solvent Disposal Area	TPH was detected below MTCA Method A criteria for diesel. No other organic compounds were detected. Metals concentrations were all below screening levels and background.	Not sampled.	No further action is recommended.
Maintenance Pit	Soil below the former Maintenance Pit could not be sampled. TPH, VOCs, and one pesticide were detected in subsurface soil south of the building: TPH and vinyl chloride exceeded MTCA Method A and MTCA Method B groundwater protection criteria, respectively. Lead was detected above MTCA Method A and EPA Region 3 criteria in surface soil south of the building. TPH, several pesticides, and several VOCs were detected in soil north of the building; TPH and several pesticides in surface soil exceeded MTCA Method A and MTCA Method B groundwater protection criteria, respectively. (An elevated detection limit for PCB analyses prevents their elimination as potential constituents of concern in surface soil in this area.) Copper was detected at a concentration above the MTCA Method B groundwater protection criteria and slightly above background (but less than two times background) in a subsurface sample collected north of the building.	Not sampled. An apparent perched water table was observed approximately 4 feet below ground surface in this area.	**Additional surface and subsurface soil sampling for TPH, VOCs, pesticides/PCBs, and lead is recommended to delineate the extent of soil contamination.** **Surface water and sediment sampling is recommended upstream and downstream from the site to determine whether the site is impacting the adjacent stream.** **Monitoring well installation and groundwater sampling for TPH, VOCs, pesticides, and PPL metals should be considered to attempt to determine whether site contamination is impacting the shallow groundwater.**

TABLE 7-1 (CONT.)
SUMMARY OF FINDINGS AND RECOMMENDATIONS

Site	Soil Results	Groundwater Results	Recommendations
Wash Rack No. 1	Elevated TPH (above MTCA Method A), cadmium (above MTCA Method B groundwater protection), and lead (above MTCA Method A and EPA Region 3) were detected in one surface soil sample. One or more pesticides and SVOCs were detected in the surface soil samples, but at concentrations below the screening criteria. Copper was detected at a concentration slightly over background (but less than two times background) in one subsurface sample.	Not sampled. An apparent perched water table was observed approximately 4 feet below ground surface in this area.	**Localized removal of petroleum and metals-contaminated soil is recommended. Proposed surface water, sediment, and groundwater sampling for the Maintenance Pit site should be designed to address the potential for contaminant migration from Wash Rack No. 1.**
Camp Bonneville Grease Pits	No organics were detected at concentrations above the screening criteria. Barium and copper were detected above the MTCA Method B groundwater protection criteria and slightly above background levels.	Not sampled. Groundwater was not encountered in the boring, which extended to volcanic rock.	No further action is recommended. Barium and copper concentrations are relatively low, as is the potential for widespread contamination.
Camp Killpack Grease Pit	No organics were detected at concentrations above the screening criteria. Arsenic was detected in one sample at a concentration above the screening criteria and slightly above background. Thallium was detected at a concentration above the MTCA Method B groundwater criterion and slightly above background in one sample.	Not sampled. Groundwater was not encountered in the boring.	No further action is recommended. Arsenic and thallium concentrations are relatively low, as is the potential for widespread contamination. Exposure would likely occur only by excavation of the grease pit.

TABLE 7-1 (CONT.)
SUMMARY OF FINDINGS AND RECOMMENDATIONS

Site	Soil Results	Groundwater Results	Recommendations
Pesticide Mixing/Storage Building	TPH and several SVOCs, pesticides, and chlorinated herbicides were detected in surface soil in front of the building. TPH slightly exceeded the MTCA Method A criterion for diesel in one sample. Other contaminants in these soils include DDE, DDT, and hexachlorobenzene, all of which were above MTCA Method B groundwater protection criteria in one or both samples. Arsenic and cadmium exceeded screening criteria and background in one or both samples. Lead exceeded the MTCA Method A criteria and background in one surface soil sample. No organic compounds (except for low levels of TPH) were detected in soil at the dry well. None of the metals detected in these samples exceeded screening criteria and background. TPH, two VOCs, and one SVOC were detected in soil samples from the upgradient and downgradient borings, but at concentrations below the screening criteria. Copper was detected in several samples at concentrations above the MTCA Method B groundwater protection criterion and slightly above background.	No organic compounds were detected in the upgradient or downgradient monitoring well. All metals detected were well below the screening criteria.	**Contaminated surface soils in the area immediately in front of the building should be excavated and disposed of properly. Confirmation sampling for TPH, pesticides, and metals should be performed to establish the lateral and vertical extent of this contamination.** No further action is recommended in the dry well area.
Aboveground Storage Tanks (ASTs)	Eight of the ASTs in the Camp Bonneville cantonment showed evidence of leakage or spillage, with chemical results from underlying soils showing high concentrations of weathered diesel. TPH concentrations in all eight samples analyzed exceeded the MTCA Method A criterion for diesel. Contamination was found at Buildings 1828, 1833, 1922 (east), 1932 (west), 1937, 1940 (north), 1942 (west), and 1980.	Not sampled.	**Contaminated soil under the eight ASTs should be excavated and properly disposed of. Confirmation sampling for WTPH-D should be performed to establish the extent of excavation required.**

TABLE 7-1 (CONT.)
SUMMARY OF FINDINGS AND RECOMMENDATIONS

Site	Soil Results	Groundwater Results	Recommendations
Former Sewage Pond	Within the former pond area, thallium was detected in one sample at a concentration above the MTCA Method B groundwater protection criteria and slightly above background. Arsenic was detected in one sample at a concentration above the screening levels and slightly above background. Copper was detected above the MTCA Method B groundwater protection criterion and slightly above background in one subsurface soil sample from the upgradient boring.	No organic compounds were detected in groundwater samples from this site. The only metal detected at a concentration above screening criteria was arsenic in the upgradient well. The arsenic concentration exceeded both MTCA and Region 3 risk-based criteria but was well below the MCL. Arsenic was not detected in the downgradient well.	No further action is recommended. Arsenic, copper, and thallium, detected in only one soil sample each at concentrations only slightly above background, may be representative of natural conditions. Arsenic concentrations in groundwater at Camp Bonneville typically appear to be slightly elevated and may be related to background conditions. Arsenic was detected only in the upgradient well at this site.
Ammunition Storage Magazines	The only explosive compound detected at a concentration above the screening criteria was RDX in the floor soil sample from within Building 2950. Elevated arsenic, cadmium, chromium, and copper (exceeding one or more of the screening criteria and background) were detected consistently in the magazine soils and the grid soil samples collected outside the magazines. Elevated barium, beryllium, nickel, thallium, and zinc (exceeding one or more of the screening criteria and background) were detected only in the outside soils, and elevated mercury and lead were detected only in the magazine soils and wipe samples. In subsurface soil samples, the only metal exceeding a screening level and background was thallium. Thallium was detected in one subsurface sample at a concentration above the MTCA Method B groundwater protection criterion and slightly above background.	Not sampled. Groundwater was not encountered in the boring, which extended to weathered volcanic rock about 6.5 feet below ground surface.	**The two small ammunition storage magazines should be cleaned to remove contaminants on the concrete. Surface and near-surface soil immediately in front of the large magazine should be sampled and analyzed for metals, explosives, and propellants.** **Installation and sampling of upgradient and downgradient monitoring wells is recommended, if possible. Soil and groundwater samples from the wells should be analyzed for metals, explosives, and propellants. Groundwater should also be analyzed for nitrates.** **Surface water and sediment sampling of Lacamas Creek is recommended to evaluate potential impacts from site contaminants. Analysis should include metals and possibly explosives, depending on the results of additional soil and groundwater analyses.** **Depending on the results of additional sampling and future site use, surface soils should be removed or capped to eliminate potential exposure or migration, with confirmation sampling to determine the extent of contamination.**

TABLE 7-1 (CONT.)
SUMMARY OF FINDINGS AND RECOMMENDATIONS

Site	Soil Results	Groundwater Results	Recommendations
Hazardous Material Accumulation Point	The only organics detected in surface soil samples were low concentrations of TPH and bis(2-ethylhexyl) phthalate (below screening levels). No metals were detected at concentrations above the screening levels and background.	Not sampled.	No further action is recommended.
Former CS Training Building	CS gas was not detected in soil samples from this site; however, several SVOCs were detected. One SVOC, benzo(b)fluoranthene, was detected at concentrations above the MTCA Method B groundwater protection criterion in two surface soil samples. The same two surface samples contained lead at concentrations above the MTCA Method A criterion; one also exceeded the EPA Region 3 criterion.	Not sampled.	**Depending on future site use, consideration should be given to removing or capping localized shallow soil contamination. Additional soil sampling will be required to determine the vertical and horizontal extent of contamination. Additional analyses for propellants may be appropriate.**
Wash Rack No. 2	The only organics detected in site soils were low concentrations of TPH (below the screening criteria). None of the metals were detected at concentrations exceeding the screening criteria and background.	Not sampled.	No further action is recommended.

Notes:
Text in **bold** indicates a recommendation for further action.
CS = 2-chlorobenzalmalononitrile (tear gas)
DDE = dichlorodiphenyldichloroethylene
DDT = dichlorodiphenyltrichloroethylene
EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level
MTCA = Washington State Model Toxics Control Act
PCB = polychlorinated biphenyl
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
SVOC = semivolatile organic compound
TPH = total petroleum hydrocarbons
VOCs = volatile organic compounds
WTPH-D = Washington Total Petroleum Hydrocarbons as Diesel

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8.0 LIMITATIONS

The findings presented in this report are based on limited investigations conducted at the subject site and should not be regarded as a definite statement regarding the reported conditions. Shannon & Wilson, Inc., conducted this investigation within its best judgment to adequately describe the known and anticipated conditions of the site. This report was prepared for the exclusive use of the U.S. Army Corps of Engineers and its representatives in the study of the Camp Bonneville facility in Vancouver, Washington, and in no way guarantees that any agency or its staff will reach the same conclusions as Shannon & Wilson, Inc.

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